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ABSTRACT

To assist teachers and students in understanding the latest concepts and functions of the automobile, this curriculum guide treats both the skills and knowledge necessary for auto mechanics. Developed by an advisory committee of instructors and mechanics in the industry, this manual consists of the following five sections: orientation and safety; measuring units and rules; engines and their systems; suspension; and brakes. Each section contains several instructional units which are organized into eight parts: (1) student behavioral objectives, which state the goals of the course; (2) suggested activities, outlining steps for both students and instructors to accomplish specific objectives; (3) information sheets, which provide the content necessary to meet the knowledge objectives of the unit; (4) transparency masters; (5) job sheets, which outline the skills being taught; (6) assignment sheets for homework or classroom use (answer sheets are also included); (7) paper-pencil and performance tests constructed to measure student achievement of each objective; and (8) test answers. (ELG)

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AUTO MECHANICS

VOLUME I

Instructional Units

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State Department of Vocational and Technical Education
Stillwater, Oklahoma

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

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ROY AYRES, STATE SUPERVISOR
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1976

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FOREWORD

This publication is another in a series of trade and industrial curriculum materials designed to assist the instructor and his/her students to understand the latest concepts and functions of the automobile. This guide will improve the quality of material presented in the shop or classroom and will bridge the gap between learning and doing. Volume one of *Auto Mechanics* has been developed by many dedicated teachers and skilled mechanics who have proven the materials workable in their own shops and classrooms. These committee members are to be commended for their tireless efforts to make this publication a useable tool of instructional techniques to better prepare the student for the challenges of the "world of work."

Roy E. Ayres, State Supervisor
Trade and Industrial Education

PREFACE

Auto mechanics instructors throughout the nation are faced with the challenge of providing students with the skills and knowledge necessary to meet the demands of our changing profession. Competition for jobs is greater than ever; therefore, the auto mechanic must be better educated in all aspects of the profession to find meaningful employment and enjoy success.

An advisory committee consisting of representatives from industry, teacher-educators, and outstanding auto mechanics instructors helped determine the units and information to be included in volume one.

The purpose of this manual is to assist auto mechanics instructors, at all levels, in providing uniform instruction throughout the industry. This publication should be supplemented by each instructor's methods and materials. The information and activities should be localized to the community and personalized to the individual student's needs.

Ivan Armstrong, Curriculum Specialist
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USE OF THIS PUBLICATION

Instructional Units

Volume one of *Auto Mechanics* includes five sections. Each section consists of several units of instruction. Each instructional unit includes behavioral objectives, suggested activities for teacher and students, information sheet, assignment sheets and/or job sheets, visual aids, tests, and answers to the test. Units are planned for more than one lesson or class period of instruction. The individual should adapt this material to the demands of the local community.

Careful study of each instructional unit by the teacher will help determine:

A. The amount of material that can be covered in each class period.
B. The skills which must be demonstrated.
    1. Supplies needed
    2. Equipment needed
    3. Amount of practice needed
    4. Amount of class time needed for demonstrations
C. Supplementary materials such as pamphlets and filmstrips that must be ordered.
D. Resource people that must be contacted.

Objectives

Each unit of instruction is based on behavioral objectives. These objectives state the goals of the course, thus providing a sense of direction and accomplishment for the student.

Behavioral objectives are stated in two forms: Unit Objectives stating the subject matter to be covered in a unit of instruction; Specific Objectives stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

Following is a list of performance terms and their synonyms which were used in this material:

Name
Label
List in writing
List orally
Letter
Record
Repeat
Give

Identify
Select
Mark
Point out
Pick out
Choose
Locate

Describe
Define
Discuss in writing
Discuss orally
Interpret
Tell how
Tell what
Explain

Order
Arrange
Sequence
List in order
Classify
Divide
Isolate
Sort

Distinguish
Discriminate

Demonstrate
Show your work
Show procedure
Perform an experiment
Perform the steps
Operate
Remove
Replace
Turn off/on
(Dis) assemble
(Dis) connect

Construct
Draw
Make
Build
Design
Formulate
Reproduce
Transcribe
Reduce
Increase
Figure
Cost

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives which will fit the material to the needs of the students and community. When a teacher adds objectives, the needed information, assignment and/or job sheets, and criterion tests should be added also.

Suggested Activities

Each unit of instruction has a Suggested Activities sheet outlining steps to follow in accomplishing specific objectives. The activities are listed according to whether they are the responsibility of the instructor or the student.

> Instructor: Duties of the instructor will vary according to the particular unit; however, for best use of the material they should include the following: provide students with objective sheet, information sheet, assignment sheets, and/or job sheets; preview filmstrips, make transparencies, and arrange for resource materials and people; discuss unit and specific objectives and information sheet; give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.
>
> Students: Student activities are listed which will help the student to achieve the objectives for the unit.

Information Sheets

Information sheets provide content essential for meeting the cognitive (knowledge) objectives of the units. The teacher will find that information sheets serve as excellent guides for presenting the background knowledges necessary to develop the skills specified in the unit objectives.

Students should read the information sheets before the information is discussed in class. Students may take additional notes on the information sheets.

Transparency Masters

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheets. They are particularly effective for such activities as identifying and locating the parts of the vehicle.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion. (NOTE: Stand away from the overhead projector when discussing transparency material. The noise of the projector may cause the teacher to speak too loudly.)

Job Sheets

Job sheets are an important segment of most units. The instructor should demonstrate the skills outlined in the job sheets. Procedures outlined in the job sheets give direction to the skill being taught and allow both student and teacher to check student progress toward the accomplishment of the skill. Job sheets provide a ready outline for a student to follow if a demonstration has been missed. Job sheets also furnish potential employers with a picture of the skills being taught and the performances which might reasonably be expected from a person who has had this training.

Assignment Sheets

Assignment sheets give direction to study and furnish practice for paper-pencil activities to develop the knowledges which are necessary prerequisites to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

Test and Evaluation

Paper-pencil and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and will help the teacher spot difficulties being encountered by students in their efforts to accomplish the unit objective. Test items for objectives added by the teacher should be constructed and added to the test.

Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

Page Numbering System

Each section in this publication is assigned a specific letter: (A) Orientation and Safety; (B) Measuring; (C) Engine; (D) Suspension; (E) Brakes. Pages are numbered consecutively within each section. For example, Orientation and Safety covers pages 1-A through 304-A. If the page is available as a transparency master, TM appears at the bottom of the page.

The following key will help to easily identify each section by color:

White - Objectives, Suggested Activities, and Transparency Masters

Green - Information Sheets

Buff - Assignment Sheets

Blue - Job Sheets

Yellow - Tests

Pink - Answers to Assignment Sheets and Answers to Tests

(NOTE: This publication will provide unity of instruction throughout Oklahoma in teaching auto mechanics. The effectiveness of this publication will depend on you as an instructor.)

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(NOTE: This is an alphabetized list of the publications used in completing this manual.)

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ORIENTATION
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to list facts concerning the occupational outlook of auto mechanics and steps involved in automotive shopwork. The student should be able to describe the VICA organization and complete a personal information sheet. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. List facts concerning the occupational outlook of auto mechanics.
2. List places that employ auto mechanics.
3. List student requirements for the auto mechanics program.
4. Name steps involved in automotive shopwork.
5. Describe the VICA organization.
6. List reasons for joining VICA.
7. Discuss the ways VICA state and national dues are used.
8. Complete a personal information sheet.

ORIENTATION
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and assignment sheets.

  C. Discuss unit and specific objectives.

  D. Discuss information and assignment sheets.

  E. Show films.

  F. Arrange a field trip to local businesses.

  G. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete assignment sheet.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Assignment Sheet #1--Personal Information Sheet

  D. Test

  E. Answers to test

II. References:

A. *Official Guide for Vocational Industrial Clubs of America.* Vocational Industrial Clubs of America, Inc.; 105 N. Virginia Avenue; Falls Church, Virginia 22046.

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(NOTE: These films are available to Oklahoma instructors from the Curriculum and Instructional Materials Center, State Department of Vocational and Technical Education, 1515 West Sixth Avenue, Stillwater, Oklahoma 74074.)

ORIENTATION
UNIT I

INFORMATION SHEET

I. Occupational outlook

   A. Job opportunities result each year from the need to replace experienced mechanics who are promoted, retire, or transfer to related fields of work

   B. The amount of vehicles increases each year requiring more mechanics to service them

   C. Added features such as air conditioning, power steering, power brakes, and exhaust emission devices increase maintenance

II. Places that employ auto mechanics

   A. Independent repair shops

   B. Service departments

   C. Car dealer agencies

   D. Service stations

   E. Automobile leasing companies

   F. Federal, state, and local government vehicle maintenance depots

III. Student requirements for the auto mechanics program

   A. Operate the shop equipment correctly

   B. Be safety conscious; follow safety regulations

   C. Take instructions readily; follow directions

   D. Be a good citizen

   E. Control temper

   F. Have enthusiasm about work

   G. Have pride in the trade

   H. Be conscious of waste in materials and man-hours

   I. Be punctual

INFORMATION SHEET

IV. Steps involved in automotive shopwork

   A. Measuring

   B. Disassembly

   C. Metal work or machining

   D. Installing new parts

   E. Reassembly

   F. Adjustments

V. VICA--Local, state, and national organization made up of students and advisors who are enrolled in or associated with trade and industrial education

VI. Reasons for joining VICA

   A. VICA brings together students with common interests so they can exchange ideas, discuss problems, and share common purposes

   B. VICA is the only national organization designed exclusively for trade, industrial, and technical students

   C. VICA offers greater leadership development opportunities

   D. VICA offers prestige and recognition through a national organization

   E. VICA offers opportunities to itself through a national program of awards and contests

   F. VICA serves to broaden perspectives through a national magazine and a system of interstate and interclub communications

   G. VICA offers cocurricular activities to give a student more than occupational skill development and to make education and training more meaningful

   H. VICA membership offers an automatic subscription to the national magazine, *VICA*, and the newsletter, *VICA News*

   I. VICA members receive membership cards as evidence of their rights and privileges as members

   J. VICA offers purchase of supplies, pins, and other club jewelry, apparel, and banners for its members

INFORMATION SHEET

VII. Ways VICA state and national dues are used

- A. National dues
  - 1. Printing
    - a. Membership cards
    - b. VICA newsletters
    - c. Information packets for clubs
    - d. VICA magazine
    - e. VICA professional news
  - 2. Contest
    - a. Awards
    - b. Space and equipment
    - c. Travel expenses
  - 3. Recurring expenses
    - a. National staff members' salaries
    - b. Office rent
    - c. Utilities, telephone, insurance, and legal fees
    - d. Office supplies
- B. State dues
  - 1. Leadership training conference
  - 2. Executive committee meetings
  - 3. Travel and expenses for
    - a. State contest winners to national contest
    - b. State officers
  - 4. State publications

ORIENTATION
UNIT I

ASSIGNMENT SHEET #1--PERSONAL INFORMATION SHEET

Complete the following personal data and turn in to the instructor.

NAME: ____

AGE: ____

BIRTH DATE: ____

GRADE CLASSIFICATION: ____

OCCUPATIONAL OBJECTIVE: ____

____

SOCIAL SECURITY NUMBER: ____

PARENTS' NAMES: ____

PARENTS' OCCUPATIONS: ____

EMERGENCY TELEPHONE NUMBER: ____

ORIENTATION
UNIT I

TEST

1. List three facts concerning the occupational outlook of auto mechanics.

   a.

   b.

   c.

2. List five places that employ auto mechanics.

   a.

   b.

   c.

   d.

   e.

3. List six student requirements for the auto mechanics program.

   a.

   b.

   c.

   d.

   e.

   f.

4. Name six steps involved in automotive shopwork.

   a.

   b.

   c.

   d.

   e.

   f.

5. Describe the VICA organization.

6. List four reasons for joining VICA.

   a.

   b.

   c.

   d.

7. Discuss the ways VICA state and national dues are used.

   a. National dues

   b. State dues

8. Complete a personal information sheet.

   (NOTE: If this has not been accomplished prior to the test, ask the instructor when the above activity should be completed.)

ORIENTATION
UNIT I

ANSWERS TO TEST

1. a. Job opportunities result each year from the need to replace experienced mechanics who are promoted, retire, or transfer to related fields of work

   b. The amount of vehicles increases each year requiring more mechanics to service them

   c. Added features such as air conditioning, power steering, power brakes, and exhaust emission devices increase maintenance

2. Any five of the following:

   a. Independent repair shops

   b. Service departments

   c. Car dealer agencies

   d. Service stations

   e. Automobile leasing companies

   f. Federal, state, and local government vehicle maintenance depots

3. Any six of the following:

   a. Operate the shop equipment correctly

   b. Be safety conscious; follow safety regulations

   c. Take instructions readily; follow directions

   d. Be a good citizen

   e. Control temper

   f. Have enthusiasm about work

   g. Have pride in the trade

   h. Be conscious of waste in materials and man-hours

   i. Be punctual

4. a. Measuring
   b. Disassembly
   c. Metal work or machining
   d. Installing new parts
   e. Reassembly
   f. Adjustments

5. VICA--Local, state, and national organization made up of students and advisors who are enrolled in or associated with trade and industrial education

6. Any four of the following:
   a. VICA brings together students with common interests so they can exchange ideas, discuss problems, and share common purposes
   b. VICA is the only national organization designed exclusively for trade, industrial, and technical students
   c. VICA offers greater leadership development opportunities
   d. VICA offers prestige and recognition through a national organization
   e. VICA offers opportunities to itself through a national program of awards and contests
   f. VICA serves to broaden perspectives through a national magazine and a system of interstate and interclub communications
   g. VICA offers cocurricular activities to give a student more than occupational skill development and to make education and training more meaningful
   h. VICA membership offers an automatic subscription to the national magazine, *VICA*, and the newsletter, *VICA News*
   i. VICA members receive membership cards as evidence of their rights and privileges as members
   j. VICA offers purchase of supplies, pins, and other club jewelry, apparel, and banners for its members

7. Discussion should include:
   a. National dues
      1) Printing
         a) Membership cards
         b) VICA newsletters

            c) Information packets for clubs
            d) VICA magazine
            e) VICA professional news
        2) Contest
            a) Awards
            b) Space and equipment
            c) Travel expenses
        3) Recurring expenses
            a) National staff members' salaries
            b) Office rent
            c) Utilities, telephone, insurance, and legal fees
            d) Office supplies
    b. State dues
        1) Leadership training conference
        2) Executive committee meetings
        3) Travel and expenses for
            a) State contest winners to national contest
            b) State officers
        4) State publications

8. Evaluated to the satisfaction of the instructor.

SAFETY
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to list rules for personal and shop safety and rules for safe use of shop equipment and materials. The student should be able to match types of fire extinguishers to the classes of fire each is best suited to extinguish and match colors of the safety color code to statements of use. The student should be able to recognize unsafe situations by completing the shop inspection checklist and be willing to sign a safety pledge form. This knowledge will be evidenced by scoring one hundred percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Define *accident, safety, first aid,* and *OSHA.*
2. Match the colors of the safety color code with statements of their use.
3. List rules for personal safety.
4. List rules for general shop safety.
5. List safety rules for hand tools such as cold chisels, hammers, pliers, screwdrivers, and vices.
6. List safety rules involving the engine.
7. List safety rules involving the battery.
8. List safety rules involving flammable liquids.
9. List safety rules for using the bench grinder, lifting devices, and portable electric drive motors.
10. Label the components of the fire triangle.
11. Match the classes of fire to the correct definitions.
12. Match types of fire extinguishers to the class of fire each is best suited to extinguish.
13. Complete the safety pledge form.
14. Complete an individual shop safety inspection.
15. Complete review questions.

SAFETY
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Show film.

   G. Invite fire chief to give a talk on fire safety.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete assignment sheets and turn in to instructor.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--The Fire Triangle

      2. TM 2--Types of Fire Extinguishers

D. Assignment sheets

1. Assignment Sheet #1--Safety Pledge Form

2. Assignment Sheet #2--Individual Student Shop Safety Inspection

3. Assignment Sheet #3--Review Questions

E. Answers to Assignment Sheet #3

F. Test

G. Answers to test

II. References:

A. Kidde Portable Extinguishers. *The ABC's of Fire Protection.* Belleville, New Jersey: Walter Kidde and Co., Inc.

B. U.S. Department of Health, Education, and Welfare, Office of Education. *An Accident Prevention Program for School Shops and Laboratories.* Department of Vocational Education, Pennsylvania State University, 1967.

C. Department of Labor. *Federal Register*, vol. 36, no. 105, pt. 2, 29 May 1971.

D. Department of Education, Division of Vocational Education, State of New Jersey. *Safety Practices and Procedures in School Shops.* Trenton: New Jersey State Department of Vocational Education.

E. *A Look at Service Safety.* Tecumseh, Michigan: Tecumseh Products Company.

III. Films:

A. "Housekeeping Means Safekeeping." 146-009. Journal Films Inc., 930 Pinter Avenue, Evanston, Illinois 60202.

B. "Stop a Fire Before It Starts." 145-024. Journal Films, 909 West Diversey Parkway, Chicago, Illinois 60614.

SAFETY
UNIT II

INFORMATION SHEET

I. Terms and definitions

   A. Safety--State or condition of being safe; freedom from danger, risk, or injury

   B. Accident--Any suddenly occurring, unintentional event which causes injury or property damage

   C. First aid--Immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

   D. OSHA--Occupational Safety and Health Act; federal legislation designed to insure safe and sanitary working conditions for employees

II. Colors and application of the safety color code

   A. Federal safety red--Basic color for the identification of:

      1. Fire protection equipment and its location

      2. Portable containers of flammable liquids

      3. Emergency stop bars, stop buttons, and emergency electrical stop switches on machinery

   B. Federal safety yellow--Basic color for designating:

      1. Caution and for marking physical hazards

      2. Waste containers for explosive or combustible materials

      3. Caution against starting, using, or moving equipment while under repair

      4. The starting point or power source of machinery

   C. Federal safety orange--Basic color for designating:

      1. Dangerous parts of machines

      2. Safety starter buttons and parts of equipment that may cause electrical shock

      3. The exposed parts (edges only) of pulleys, gears, rollers, cutting devices, and power jaws

INFORMATION SHEET

D. Federal safety purple--Basic color for designating radiation hazards

E. Federal safety green--Basic color for designating:

1. Safety

2. Location of first aid equipment

   (NOTE: This applies to equipment other than fire fighting equipment.)

F. Federal safety black and white (used individually or in combination)--Basic colors for designating:

1. Traffic flow

2. Housekeeping purposes

3. Storage areas

III. Personal safety rules

A. Wear shop clothing appropriate to the instructional activity being performed

B. Confine long hair before operating rotating equipment

C. Wear safety glasses; use suitable helmets and goggles for welding

D. Remove ties when working around machine tools or rotating equipment

E. Remove rings and other jewelry when working in the shop

F. Conduct yourself in a manner conducive to safe shop practices

G. Use soap and water frequently as a method of preventing skin diseases

IV. General shop safety rules

A. Move heavy objects only with supervision by the instructor

B. Retain all guards and safety devices on power equipment

C. Report defective tools, machines, or other equipment to the instructor

D. Report all accidents to the instructor regardless of the nature or severity

INFORMATION SHEET

E. Disconnect the power from machines and equipment before performing any maintenance task

F. Keep the laboratory or shop floor clear of scraps and litter

G. Store oily shop towels in metal containers

H. Walk in the shop

I. Operate a hazardous machine only after receiving instructions on its safe use

J. Do not horseplay in the auto shop

K. Use compressed air for its intended purpose

(CAUTION: An air blast must not be directed toward another person.)

L. Do not leave creepers, tools, and equipment where someone can trip or step on them

M. Make sure all cotter keys, bolts, and lock washers are in place and secure

N. Handle brake fluid carefully to prevent it from coming in contact with eyes, skin, or vehicle paint

O. Report all hazardous conditions to the instructor immediately

V. Safety rules involving hand tools

A. General hand tools

1. Use the proper tool for the job
2. Keep tools in good condition
3. Clean and return tools to the proper storage area after use
4. Use all hand tools properly

B. Cold chisels

1. Use sharp cold chisels without mushroomed ends
2. Use a full face shield when using the cold chisel

INFORMATION SHEET

3. Hold the cold chisel firmly against the work when striking it with a hammer

4. Select the correct size and shape of cold chisel for the job

C. Screwdrivers

1. Avoid using the screwdriver for any job other than turning screws

2. Use a screwdriver that fits the screw to be turned in both slot width and length

3. Avoid holding the work in one hand and screwdriver in the other

   (NOTE: The screwdriver can slip from the screw slot and injure the hand holding the work.)

4. Use only screwdrivers that are in good condition and free from cracked, rough, or split handles

D. Pliers

1. Do not use pliers to loosen or tighten gas lines, bolts, or nuts

2. Cut wire under tension only after securing or covering both ends to prevent them from flying into your face

E. Hammers

1. Wear a full face shield when hammering anything that can chip or flake

2. Make sure the handle is tight and the hammer is in good condition before using

3. Keep the handle of the hammer clean and free from grease to prevent it from slipping out of your hand

F. Vises

1. Make sure the vise is heavy enough for the work being done

2. Close the vise and turn the handle down after using

3. Tighten the vise by using downward pressure on the handle

INFORMATION SHEET

4. Use pipe vise inserts or "V" blocks when working with round stock

5. Hold the object clamped in the vise firmly before loosening it to prevent the object from falling out

VI. Safety rules involving the engine

A. Operate engines under close supervision of the instructor and only if the shop has an exhaust gas removing system

B. Use caution to prevent contact with hot manifolds and hoses when working on a hot engine

C. Do not pour gasoline into the carburetor when starting an engine

(NOTE: If priming is necessary check with the instructor who will issue rules consistent with the existing situation.)

D. Get into the vehicle and make sure it is out of gear and everyone is clear before starting engine

VII. Battery safety

A. Keep sparks and flame away from batteries

(CAUTION: The accumulation of hydrogen in the top of the cells during the charging process is very explosive.)

B. Remove the ground cable first when removing a battery from a vehicle and connect it last when installing the battery

C. Make sure the battery charger is turned off before removing the leads from the battery parts

D. Do not lay tools on top of the battery

E. Use a battery strap to remove, replace, or transport a battery

VIII. Safety rules involving flammable liquids

A. Store all flammable liquids in approved safety containers

B. Do not operate engine if there is fuel leaking from the carburetor, fuel pump, or fuel line

C. Do not use gasoline to clean parts

(NOTE: Use only approved cleaning solvents.)

INFORMATION SHEET

D. Change oil or gasoline soaked clothing immediately

E. Bring into the shop only sufficient flammable liquids for immediate use

F. Learn the location and use of fire extinguishers for flammable liquid fires

IX. Equipment safety rules

A. Bench grinder

1. Use a full face shield while using the grinder or buffer wheels
2. Keep tool rest in place and properly adjusted before operating the grinder
3. Do not overload the grinder motor
4. Use suitable hand protection when operating the grinder

B. Lifting devices

1. Make sure the jack is squarely on the frame area of the vehicle before lifting
2. Position the jack handles to prevent someone from tripping over them
3. Secure the vehicle on safety jack stands before working under a vehicle
4. Make sure all persons and obstructions are clear before raising or lowering a vehicle
5. Make sure bolts attaching the engine pulling chain or cable to the engine are the correct length and of suitable tensile strength
6. Have the instructor inspect the engine-pulling equipment before lifting the engine
7. Position the crane or hoist directly over the object to be lifted
8. Use all safety devices provided with the crane or hoist
9. Operate all pneumatic or electric hoists strictly by the manufacturer's instructions

INFORMATION SHEET

C. Portable electric drive motors

Examples: Drills and grinders

1. Make sure switches are in the OFF position before plugging the cord into an electrical outlet
2. Do not engage chuck keys or shaft locks until the electrical cord is unplugged
3. Operate electrical equipment only when the floor, cord, cord plug, and motor are dry
4. Wear protective face shield and hand and body protection when operating grinders, polishers, and other high speed equipment
5. Hold equipment securely and in the proper position to prevent accidental contact with the body
6. Ground all equipment properly before using

X. Components of the fire triangle (Transparency 1)

- A. Fuel
- B. Heat
- C. Oxygen

XI. Classes of fire

- A. Class A--Fires that occur in ordinary combustible materials such as wood, rags, and rubbish
- B. Class B--Fires that occur with flammable liquids such as gasoline, oil, grease, paint, and thinners
- C. Class C--Fires that occur in or near electrical equipment such as motors, switchboards, and electrical wiring
- D. Class D--Fires that occur with combustible metals such as iron and magnesium

XII. Types of fire extinguishers (Transparency 2)

- A. Pressurized water--Used on class A fires
- B. Soda acid--Used on class A fires

INFORMATION SHEET

C. Carbon dioxide (CO_2)--Used on class B and C fires

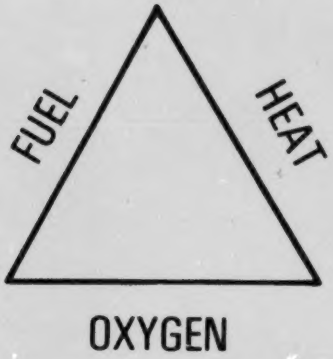
D. Dry chemical--Used on class B, C, and D fires

(NOTE: On class D fires, dry sand is as effective as any dry chemical other than Purple X. The cost of Purple X chemical places it out of reach of most shops.)

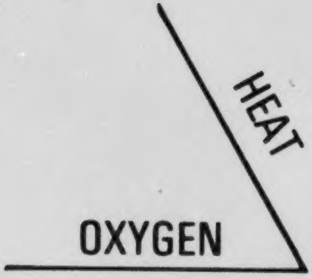
E. Foam--Used on class A and B fires

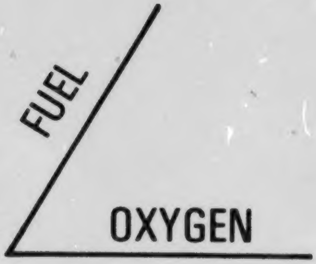
The Fire Triangle

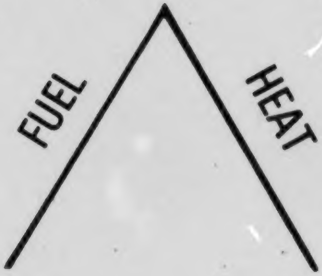
To produce fire, three things must be present at the same time.


FUEL
HEAT
OXYGEN

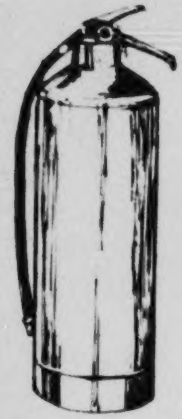
If any one of the three is missing, a fire cannot be started or, with the removal of any one, the fire will be extinguished.


HEAT
OXYGEN

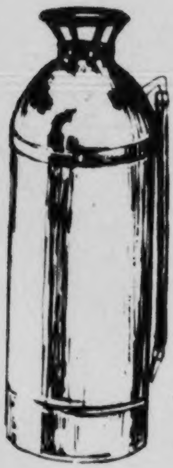

FUEL
OXYGEN



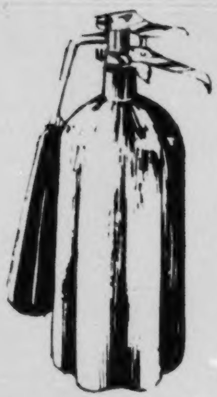
Types of Fire Extinguishers



Pressurized Water

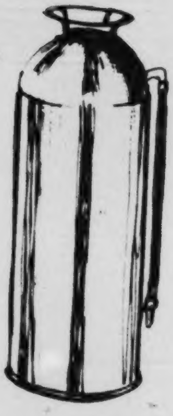


Soda-Acid



Carbon Dioxide

Dry Chemical



Foam

AM I - 31-A

SAFETY
UNIT II

ASSIGNMENT SHEET #1--SAFETY PLEDGE FORM

Read the student safety pledge form and complete by filling in the blanks. Return form to instructor no later than ____________________.

STUDENT SAFETY PLEDGE FORM

______________________________, who is enrolled in Vocational __________

__________, will, as a part of the shop experience, operate machines, providing that

his/her parent or guardian gives written permission.

It is understood that each student will be given proper instruction, both in the use of the equipment and in correct safety procedures concerning it, before being allowed to operate it alone. The student must assume responsibility for following safe practices, and we therefore ask that the student subscribe to the following safety pledge.

1. I PROMISE TO FOLLOW ALL SAFETY RULES FOR THE SHOP.
2. I PROMISE NEVER TO USE A MACHINE WITHOUT FIRST HAVING PERMISSION FROM THE INSTRUCTOR.
3. I WILL NOT ASK PERMISSION TO USE A PARTICULAR MACHINE UNLESS I HAVE BEEN INSTRUCTED IN ITS USE AND HAVE MADE 100% ON THE SAFETY TEST FOR THAT MACHINE.
4. I WILL REPORT ANY ACCIDENT OR INJURY TO THE TEACHER IMMEDIATELY.

DATE __________ STUDENT'S SIGNATURE ____________________

I hereby give my consent to allow my son or daughter to operate all machines and equipment necessary in carrying out the requirements of the course in which he/she is enrolled.

DATE __________ PARENT'S SIGNATURE ____________________

Parents are cordially invited to visit the shop to inspect the machines and to see them in operation.

(NOTE: Parental consent is necessary only if the student is a minor.)

SAFETY
UNIT II

ASSIGNMENT SHEET #2--INDIVIDUAL STUDENT SHOP SAFETY INSPECTION

Complete the safety inspection checklist by physically conducting an inspection of the shop area.

CHECKING PROCEDURE

Draw a circle around the appropriate letter, using the following letter scheme:

S -- Satisfactory (needs no attention)
A -- Acceptable (needs some attention)
U -- Unsatisfactory (needs immediate attention)

Recommendations should be made in all cases where a "U" is circled. Space is provided at the end of the form for such comments.

GENERAL PHYSICAL CONDITION

1.	Machines, benches, and other equipment are arranged so as to conform to good safety practices	S	A	U
2.	Condition of stairways and ramps	S	A	U
3.	Condition of aisles	S	A	U
4.	Condition of floors	S	A	U
5.	Condition of walls, windows, and ceiling	S	A	U
6.	Illumination is safe, sufficient, and well placed	S	A	U
7.	Ventilation is adequate and proper for conditions	S	A	U
8.	Temperature control	S	A	U
9.	Fire extinguishers are of proper type, adequately supplied, properly located, and maintained	S	A	U
10.	Teacher and pupils know location of and how to use proper type of extinguisher for various fires	S	A	U
11.	Number and location of exits is adequate and properly identified	S	A	U

ASSIGNMENT SHEET #2

12. Walls are clear of objects that might fall S A U
13. Utility lines are properly identified S A U
14. Air in shop is free from excessive dust and smoke S A U
15. Evaluation for the total rating of GENERAL PHYSICAL CONDITION S A U

HOUSEKEEPING

1. General appearance as to orderliness S A U
2. Adequate and proper storage space for tools and materials S A U
3. Benches are kept orderly S A U
4. Corners are clean and clear S A U
5. Special tool racks in orderly condition and provided at benches and machines S A U
6. Tool, supply, and/or material room is orderly S A U
7. Sufficient scrap boxes are provided S A U
8. Scrap stock is put in scrap boxes promptly S A U
9. Materials are stored in an orderly and safe condition S A U
10. A spring lid metal container is provided for waste and oily rags S A U
11. Dangerous materials are stored in metal cabinets S A U
12. Machines have been color conditioned S A U
13. Safety cans are provided for flammable liquids S A U
14. Floors are free of oil, water, and foreign material S A U
15. Evaluation for the total rating for HOUSEKEEPING S A U

ASSIGNMENT SHEET #2

EQUIPMENT

1. Machines are arranged so that workers are protected from hazards of other machines and passing students S A U
2. Danger zones are properly indicated and guarded S A U
3. All gears and moving belts are protected by permanent enclosure guards S A U
4. All equipment control switches are easily available to operator S A U
5. Nonskid areas are provided around machines S A U
6. Tools are kept sharp, clean and in safe working order S A U
7. Evaluation for the total rating for EQUIPMENT S A U

ELECTRICAL INSTALLATION

1. All switches are enclosed S A U
2. There is a master control switch for all of the electrical installations S A U
3. All electrical extension cords are in safe condition and are not carrying excessive loads S A U
4. All machine switches are within easy reach of the operators S A U
5. Individual cut-off switches are provided for each machine S A U
6. No temporary wiring in evidence S A U
7. Evaluation for the total rating for ELECTRICAL INSTALLATION S A U

SAFETY
UNIT II

ASSIGNMENT SHEET #3--REVIEW QUESTIONS

Circle the letter next to the correct answer to each question.

1. A sudden occurring, unintentional event which causes injury or property damage is the definition of:
    a. Accident
    b. First aid
    c. Safety
    d. Color code

2. A condition of being safe; freedom from danger, risk, or injury is the definition of:
    a. Safety
    b. First aid
    c. Color code
    d. Accident

3. The immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained is the definition of:
    a. Safety
    b. Color code
    c. First aid
    d. Accident

4. The color applied to nonmoving objects such as hand rails, traffic lanes, and hazardous areas that may cause stumbling, falling, or tripping is:
    a. Yellow
    b. Green
    c. Orange
    d. Red

5. The color applied to noncritical parts of equipment, name plates, and first aid equipment is:
    a. Red
    b. Purple
    c. Green
    d. Blue

ASSIGNMENT SHEET #3

6. The color applied to electrical boxes and switches, movable guards, and parts that may cut, crush, shock, or otherwise injure is:

   a. Yellow
   b. Green
   c. White
   d. Orange

7. The color applied to identify the location of fire fighting equipment is:

   a. Orange
   b. Red
   c. Yellow
   d. White

8. The color applied as a basic color indicating caution against starting equipment while under repair is:

   a. Blue
   b. Red
   c. Orange
   d. Yellow

9. The color applied to areas for storage and to show traffic flow is:

   a. Orange
   b. Red
   c. White
   d. Purple

10. The color applied to areas involving radiation is:

    a. Orange
    b. Yellow
    c. White
    d. Purple

11. In the auto shop you should conduct yourself in a manner:

    a. Involving horseplay
    b. Of your choice
    c. Conducive to safe shop practices
    d. Cautiously when the instructor is watching

12. When working in the auto shop you should always wear:

    a. Rings and other jewelry
    b. Safety glasses
    c. Gloves
    d. Sandals

ASSIGNMENT SHEET #3

13. Heavy objects should be moved:
    a. Only with supervision by the instructor
    b. With a chain hoist
    c. With the help of another student
    d. By the easiest way possible

14. Defective tools, machines, or other equipment should be:
    a. Pushed back against the wall
    b. Reported to a student
    c. Used as well as possible
    d. Reported to the instructor

15. All accidents regardless of the nature or severity should be:
    a. Kept secret
    b. Reported to the instructor
    c. Reported to your shop partner
    d. Ignored if not serious

16. Oily shop towels should be stored in a:
    a. Metal container
    b. Wooden box
    c. Corner
    d. Locker

17. When moving about the shop you should:
    a. Run occasionally
    b. Run
    c. Walk
    d. Skip

18. A hazardous machine should be operated only after:
    a. Plugging in the power cord
    b. Receiving instruction on its safe use
    c. Putting on suitable work clothes
    d. Removing the guards and safety devices

19. Creepers, tools, and other equipment should be:
    a. Left wherever they were used
    b. Placed where no one can trip or fall on them
    c. Pushed under the workbench
    d. Left for someone else to store

ASSIGNMENT SHEET #3

20. A job must not be considered complete until:
    - a. Your friend says it's okay
    - b. The repair bill is totaled
    - c. The vehicle goes out of the shop
    - d. All cotter keys, bolts, and lock washers are in place and secure

21. Brake fluid should be handled carefully to prevent it from:
    - a. Saturating the wheel cylinder
    - b. Coming in contact with eyes, skin, or vehicle paint
    - c. Exploding
    - d. Atomizing

22. When using the cold chisel, it should be:
    - a. Dull to prevent injury
    - b. Warm and clean
    - c. Cold and gloves should be worn
    - d. Sharp and without a mushroomed end

23. When using the cold chisel:
    - a. Wear a full face shield
    - b. Wear safety goggles only
    - c. Wear colored glasses
    - d. Eye protection is not required

24. Screwdrivers should be used only for the purpose of:
    - a. Opening paint cans
    - b. Turning screws
    - c. Removing hubcaps
    - d. Opening oil cans

25. Use a screwdriver that fits the screw to be turned:
    - a. In length only
    - b. In slot width only
    - c. In both slot width and length
    - d. Unimportant as to how it fits

26. When cutting wire under tension:
    - a. Secure one end of the wire only
    - b. Hold the side cutters or pliers with both hands
    - c. Secure or cover both ends of the wire
    - d. Hold the side cutters or pliers with one hand and observe the cut closely

ASSIGNMENT SHEET #3

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    - b. With a chain hoist
    - c. With the help of another student
    - d. By the easiest way possible

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    - b. Run
    - c. Walk
    - d. Skip

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    - b. Receiving instruction on its safe use
    - c. Putting on suitable work clothes
    - d. Removing the guards and safety devices

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    - b. Placed where no one can trip or fall on them
    - c. Pushed under the workbench
    - d. Left for someone else to store

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    b. Hold the side cutters or pliers with both hands
    c. Secure or cover both ends of the wire
    d. Hold the side cutters or pliers with one hand and observe the cut closely

ASSIGNMENT SHEET #3

27. When hammering anything that can chip or flake:

    a. Wear sunglasses
    b. Wear colored glasses with the correct lens
    c. Wear a full face shield
    d. Eye protection is not required

28. When finished using the vise:

    a. Close the vise and turn the handle down
    b. Leave the vise open
    c. Leave the vise open with the handle down
    d. Close the vise and turn the handle up

29. To tighten the vise use:

    a. A hammer
    b. Downward pressure strokes
    c. Upward pressure strokes
    d. Place the sliding handle in the middle and use both up and down pressure strokes

30. Engines should be operated under close supervision of the instructor and only:

    a. If a suitable exhaust gas removing system is used
    b. If a shop window is open
    c. If the car windows are closed
    d. If the hood is shut

31. If priming an engine is necessary:

    a. Pour gas in the carburetor
    b. Check with the instructor who will issue rules consistent with the existing conditions
    c. Blow in the gas tank
    d. Hold your hand over the top of the carburetor

32. When starting a vehicle:

    a. Reach through the window to start it
    b. Get into the vehicle and make sure it is out of gear and everyone is clear
    c. Short across the starter switch under the hood
    d. Open the door and reach in to start the vehicle

ASSIGNMENT SHEET #3

33. Flammable liquids must be stored in:
    a. Glass containers
    b. Plastic jugs
    c. Metal cans without lids
    d. Approved safety containers

34. If fuel is leaking from the fuel pump or fuel lines or carburetor:
    a. The engine is fine for temporary service
    b. The engine must not be operated
    c. The engine can be operated for a few minutes
    d. It will not effect the operation of the engine

35. If shop clothing becomes soaked with gasoline or oil:
    a. Use caution around the arc welder
    b. Run water over the soaked area
    c. Wear them until the end of class
    d. Change them immediately

36. When cleaning parts use:
    a. Gasoline
    b. Water
    c. Approved solvent
    d. Carbon dioxide

37. Sparks and flames must be kept away from batteries as the accumulation of hydrogen in the top of the cell is:
    a. Not fireproof
    b. Explosive
    c. Frozen and should not be thawed
    d. Heat resistant

38. Before removing the battery charger leads from the battery post, make sure the battery charger is:
    a. Turned off
    b. Turned on
    c. Set on the correct voltage
    d. Not overheated

39. Before grinding small or irregular pieces on the grinder:
    a. Get a friend to help you
    b. Get a small or irregular grinding wheel
    c. Get a large grinding wheel
    d. Get permission and special instructions from the instructor

ASSIGNMENT SHEET #3

40. Before lifting a vehicle make sure the jack is:

    a. Positioned directly over the object
    b. Of correct length and suitable tensile strength
    c. Clean and lubricated
    d. Positioned correctly and properly centered

41. Before working under a vehicle make sure the jack stands are:

    a. Clean and lubricated
    b. In place and properly positioned
    c. Sitting under the workbench
    d. Free from obstructions

42. The bolts used to secure an engine pulling chain or cable must be:

    a. Made of soft iron
    b. Free from obstructions
    c. Positioned directly over the object
    d. The correct length and of suitable tensile strength

43. Before lifting an engine make sure the setup is checked by:

    a. The instructor
    b. Another student
    c. Your partner
    d. The toolroom man

44. When using the crane or hoist to lift, it should be:

    a. Positioned to the left side of the object
    b. Positioned to the right side of the object
    c. Positioned under the object
    d. Positioned directly over the object

45. When using the portable electric drill, make sure the chuck key is:

    a. Placed in the toolroom
    b. Removed from the chuck immediately after using
    c. Engaged only after electrical cord is unplugged
    d. Secured to the ground wire

46. Before using portable electric equipment make sure the drive motor, cord, and floor are:

    a. Cold
    b. Wet
    c. Dry
    d. Warm

ASSIGNMENT SHEET #3

47. During honing and drilling operations the portable electric drill should be held:

    a. Gently
    b. Lightly
    c. Loosely
    d. Securely

48. When using portable electric equipment, make sure the ground wire is:

    a. Properly attached
    b. Disconnected
    c. Removed completely
    d. Wrapped around the cord

SAFETY
UNIT II

ANSWERS TO ASSIGNMENT SHEET #3

1. a
2. a
3. c
4. a
5. c
6. d
7. b
8. d
9. c
10. d
11. c
12. b
13. a
14. d
15. b
16. a
17. c
18. b
19. b
20. d
21. b
22. d
23. a
24. b
25. c
26. c
27. c
28. a
29. b
30. a
31. b
32. b
33. d
34. b
35. d
36. c
37. b
38. a
39. d
40. d
41. b
42. d
43. a
44. d
45. c
46. c
47. d
48. a

SAFETY
UNIT II

TEST

1. Define the following terms.

   a. Safety--

   b. Accident--

   c. First aid--

   d. OSHA--

2. Match the following colors of the safety color code with the correct statements of their use. Blanks may have more than one answer.

   _____a. Designates caution

   _____b. Used to identify the locations of fire fighting equipment

   _____c. Designates the location of safety and first aid equipment

   _____d. Designates dangerous parts of machinery that may cause injury

   _____e. Designates caution against starting, using, or moving equipment while under repair

   _____f. Designates traffic flow

   _____g. Designates radiation hazards

   1. Green
   2. White
   3. Orange
   4. Purple
   5. Black
   6. Red
   7. Yellow

3. List five personal safety rules.

   a.

   b.

   c.

   d.

   e.

4. List ten rules for general shop safety.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

   h.

   i.

   j.

5. List two safety rules for each of the following hand tools.

   a. General hand tools

      1)

      2)

   b. Cold chisels

      1)

      2)

   c. Screwdrivers

      1)

      2)

d. Pliers

 1)

 2)

e. Hammers

 1)

 2)

f. Vises

 1)

 2)

6. List four safety rules involving the engine.

 a.

 b.

 c.

 d.

7. List five safety rules involving the battery.

 a.

 b.

 c.

 d.

 e.

8. List five safety rules involving flammable liquids.

   a.

   b.

   c.

   d.

   e.

9. List four safety rules for using each of the following types of equipment.

   a. Bench grinder

      1)

      2)

      3)

      4)

   b. Lifting devices

      1)

      2)

      3)

      4)

c. Portable electric drive motors

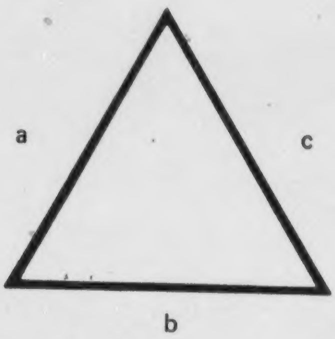
1)

2)

3)

4)

10. Label the components of the following fire triangle.



a. ______________________

b. ______________________

c. ______________________

11. Match the classes of fire on the right to the correct definitions.

_____a. Fires that occur with flammable liquids such as gasoline, oil, grease, paint, and thinners

_____b. Fires that occur in ordinary combustible materials such as wood, rags, and rubbish

_____c. Fires that occur in or near electrical equipment such as motors, switchboards, and electrical wiring

_____d. Fires that occur with combustible metals such as iron and magnesium

1. Class A
2. Class B
3. Class C
4. Class D

12. Match the types of fire extinguishers on the right to the class or classes of fire each is best suited to extinguish. Blanks may have more than one answer.

_______a. Fires that occur with flammable liquids such as gasoline, oil, grease, paint, and thinners

_______b. Fires that occur in or near electrical equipment such as motors, switchboards, and electrical wiring

_______c. Fires that occur in ordinary combustible materials such as wood, rags, and rubbish

_______d. Fires that occur with combustible metals such as iron and magnesium

1. Pressurized water
2. Carbon dioxide (CO_2)
3. Dry chemical
4. Soda acid
5. Foam

13. Complete the safety pledge form.

14. Complete an individual shop safety inspection.

15. Complete review questions.

(NOTE: If these activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

SAFETY
UNIT II

ANSWERS TO TEST

1. a. State or condition of being safe; freedom from danger, risk, or injury

   b. Any suddenly occurring, unintentional event which causes injury or property damage

   c. Immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

   d. Occupational Safety and Health Act; federal legislation designed to insure safe and sanitary working conditions for employees

2. a. 7
   b. 6
   c. 1
   d. 3
   e. 7
   f. 2 and 5
   g. 4

3. Any five of the following:

   a. Wear shop clothing appropriate to the instructional activity being performed

   b. Confine long hair before operating rotating equipment

   c. Wear safety glasses; use suitable helmets and goggles for welding

   d. Remove ties when working around machine tools or rotating equipment

   e. Remove rings and other jewelry when working in the shop

   f. Conduct yourself in a manner conducive to safe shop practices

   g. Use soap and water frequently as a method of preventing skin diseases

4. Any ten of the following:

   a. Move heavy objects only with supervision by the instructor

   b. Retain all guards and safety devices on power equipment

   c. Report defective tools, machines, or other equipment to the instructor

d. Report all accidents to the instructor regardless of the nature or severity

e. Disconnect the power from machines and equipment before performing any maintenance task

f. Keep the laboratory or shop floor clear of scraps and litter

g. Store oily shop towels in metal containers

h. Walk in the shop

i. Operate a hazardous machine only after receiving instructions on its safe use

j. Do not horseplay in the auto shop

k. Use compressed air for its intended purpose

l. Do not leave creepers, tools, and equipment where someone can trip or step on them

m. Make sure all cotter keys, bolts, and lock washers are in place and secure

n. Handle brake fluid carefully to prevent it from coming in contact with eyes, skin, or vehicle paint

o. Report all hazardous conditions to the instructor immediately

5. Any two of the following from each group:

a. General hand tools

    1) Use the proper tool for the job

    2) Keep tools in good condition

    3) Clean and return tools to the proper storage area after use

    4) Use all hand tools properly

b. Cold chisels

    1) Use sharp cold chisels without mushroomed ends

    2) Use a full face shield when using the cold chisel

    3) Hold the cold chisel firmly against the work when striking it with a hammer

    4) Select the correct size and shape of cold chisel for the job

c. Screwdrivers

   1) Avoid using the screwdriver for any job other than turning screws

   2) Use a screwdriver that fits the screw to be turned in both slot width and length

   3) Avoid holding the work in one hand and screwdriver in the other

   4) Use only screwdrivers that are in good condition and free from cracked, rough, or split handles

d. Pliers

   1) Do not use pliers to loosen or tighten gas lines, bolts, or nuts

   2) Cut wire under tension only after securing or covering both ends to prevent them from flying into your face

e. Hammers

   1) Wear a full face shield when hammering anything that can chip or flake

   2) Make sure the handle is tight and the hammer is in good condition before using

   3) Keep the handle of the hammer clean and free from grease to prevent it from slipping out of your hand

f. Vises

   1) Make sure the vise is heavy enough for the work being done

   2) Close the vise and turn the handle down after using

   3) Tighten the vise by using downward pressure on the handle

   4) Use pipe vise inserts or "V" blocks when working with round stock

   5) Hold the object clamped in the vise firmly before loosening it to prevent the object from falling out

6. a. Operate engines under close supervision of the instructor and only if the shop has an exhaust gas removing system

   b. Use caution to prevent contact with hot manifolds and hoses when working on a hot engine

- c. Do not pour gasoline into the carburetor when starting an engine
- d. Get into the vehicle and make sure it is out of gear and everyone is clear before starting engine

7. a. Keep sparks and flame away from batteries
   - b. Remove the ground cable first when removing a battery from a vehicle and connect it last when installing the battery
   - c. Make sure the battery charger is turned off before removing the leads from the battery parts
   - d. Do not lay tools on top of the battery
   - e. Use a battery strap to remove, replace, or transport a battery

8. Any five of the following:
   - a. Store all flammable liquids in approved safety containers
   - b. Do not operate engine if there is fuel leaking from the carburetor, fuel pump, or fuel line
   - c. Do not use gasoline to clean parts
   - d. Change oil or gasoline soaked clothing immediately
   - e. Bring into the shop only sufficient flammable liquids for immediate use
   - f. Learn the location and use of fire extinguishers for flammable liquid fires

9. Any four of the following from each group:
   - a. Bench grinder
     - 1) Use a full face shield while using the grinder or buffer wheels
     - 2) Keep tool rest in place and properly adjusted before operating the grinder
     - 3) Do not overload the grinder motor
     - 4) Use suitable hand protection when operating the grinder
   - b. Lifting devices
     - 1) Make sure the jack is squarely on the frame area of the vehicle before lifting
     - 2) Position the jack handles to prevent someone from tripping over them

3) Secure the vehicle on safety jack stands before working under a vehicle

4) Make sure all persons and obstructions are clear before raising or lowering a vehicle

5) Make sure bolts attaching the engine pulling chain or cable to the engine are the correct length and of suitable tensile strength

6) Have the instructor inspect the engine-pulling equipment before lifting the engine

7) Position the crane or hoist directly over the object to be lifted

8) Use all safety devices provided with the crane or hoist

9) Operate all pneumatic or electric hoists strictly by the manufacturer's instructions

c. Portable electric drive motors

1) Make sure switches are in the OFF position before plugging the cord into an electrical outlet

2) Do not engage chuck keys or shaft locks until the electrical cord is unplugged

3) Operate electrical equipment only when the floor, cord, cord plug, and motor are dry

4) Wear protective face shield and hand and body protection when operating grinders, polishers, and other high speed equipment

5) Hold equipment securely and in the proper position to prevent accidental contact with the body

6) Ground all equipment properly before using

10. a. Fuel

b. Heat

c. Oxygen

11. a. 2

b. 1

c. 3

d. 4

12. a. 2, 3, and 5
    b. 2 and 3
    c. 1, 4, and 5
    d. 3
13. Evaluated to the satisfaction of the instructor
14. Evaluated to the satisfaction of the instructor
15. Evaluated to the satisfaction of the instructor

HAND TOOLS
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify hand tools, general shop tools, and special tools for each major area of vehicle repair. The student should be able to sharpen and repair specific hand tools. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Write the purpose of tools.
2. Identify types of screwdrivers.
3. Identify types of pliers.
4. Identify types of wrenches.
5. Identify the components of a socket set.
6. Identify types of sockets.
7. Identify types of special purpose sockets.
8. Identify the types of hammers used in the auto shop.
9. Identify types of punches.
10. Identify types of chisels.
11. Identify types of files
12. Identify types of file teeth.
13. Identify types of parts cleaning tools.
14. Identify types of general shop tools.
15. Identify tools used to service the battery.
16. Identify tools used to service the starting system.
17. Identify tools used to service the charging system.

18. Identify tools used to service the ignition system.
19. Identify tools used to service the fuel system.
20. Identify tools used to service the exhaust system.
21. Identify tools used to service the cooling system.
22. Identify tools used in lubrication service work.
23. Identify tools used to service the brake system.
24. Identify tools used to service front ends.
25. Identify tools used in engine repair.
26. Identify tools used to service the drive line.
27. Demonstrate the ability to:
    a. Sharpen a twist drill.
    b. Drill holes with a drill press.
    c. Reshape a cold chisel.
    d. Cut flat metal with a cold chisel.
    e. Dress a grinding wheel.
    f. Fit a screwdriver.
    g. Replace a hammer handle.
    h. Check a torque wrench for accuracy.
    i. Draw file a flat surface.
    j. Draw a twist drill hole to correct center.

HAND TOOLS
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined on the job sheets.

   G. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Demonstrate the ability to accomplish the procedures outlined on the job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Types of Screwdrivers

      2. TM 2--Types of Pliers

      3. TM 3--Types of Wrenches

      4. TM 4--Types of Wrenches (Continued)

5. TM 5--Components of a Socket Set
6. TM 6--Types of Sockets
7. TM 7--Special Purpose Sockets
8. TM 8--Types of Hammers
9. TM 9--Types of Punches
10. TM 10--Types of Chisels
11. TM 11--Types of Files
12. TM 12--Types of File Teeth
13. TM 13--Types of Parts Cleaning Tools
14. TM 14--General Shop Tools
15. TM 15--General Shop Tools (Continued)
16. TM 16--General Shop Tools (Continued)
17. TM 17--Battery Service Tools
18. TM 18--Starter Service Tools
19. TM 19--Charging System Service Tools
20. TM 20--Ignition Service Tools
21. TM 21--Fuel System Service Tools
22. TM 22--Exhaust System Service Tools
23. TM 23--Cooling System Service Tools
24. TM 24--Lubrication Service Tools
25. TM 25--Brake Service Tools
26. TM 26--Front-End Service Tools
27. TM 27--Engine Repair Tools
28. TM 28--Engine Repair Tools (Continued)
29. TM 29--Drive Line Tools

D. Job sheets

1. Job Sheet #1--Sharpen a Twist Drill
2. Job Sheet #2--Drill Holes with a Drill Press
3. Job Sheet #3--Reshape a Cold Chisel
4. Job Sheet #4--Cut Flat Metal with a Cold Chisel
5. Job Sheet #5--Dress a Grinding Wheel
6. Job Sheet #6--Fit a Screwdriver
7. Job Sheet #7--Replace a Hammer Handle
8. Job Sheet #8--Check Torque Wrench for Accuracy
9. Job Sheet #9--Draw File a Flat Surface
10. Job Sheet #10--Draw a Twist Drill Hole to Correct Center

E. Test

F. Answers to test

II. References:

A. *Shop Tools.* Fundamentals of Service series. Moline, Illinois: Deere and Company, 1971.

B. *ABC's of Hand Tools.* Detroit, Michigan: General Motors Corporation, General Motors Building, 1945.

HAND TOOLS
UNIT III

INFORMATION SHEET

I. Purpose of tools--To allow the mechanic to perform a variety of service procedures quickly and effectively

II. Types of screwdrivers (Transparency 1)

  A. Standard or common

  B. Phillips

  C. Clutch

  D. Reed and prince

  E. Offset

III. Types of pliers (Transparency 2)

  A. Slip joint

  B. Channel lock

  C. Needle nose

  D. Diagonal side cutter

  E. Lock grip

IV. Types of wrenches (Transparencies 3 and 4)

  A. Open end

  B. Box end

  C. Combination end

  D. Obstruction box end

  E. Flex head

  F. Tubing wrench

  G. Adjustable end wrench

  H. Pipe wrench

INFORMATION SHEET

V. Components of a socket set (Transparency 5)

  A. Break-over handle

  B. Ratchet handle

  C. Speed handle

  D. Extension

  E. Universal joint

  F. Socket

  G. Sliding T-handle

VI. Types of sockets (Transparency 6)

  A. Standard

  B. Deep well

  C. Universal

  (NOTE: Most sockets come in either six or twelve point.)

VII. Special purpose sockets (Transparency 7)

  A. Phillips

  B. Standard

  C. Clutch

  D. Allen or hex head

  E. Triple square cap

  F. Drag link

  G. Shock absorber

  H. Prong nut or dash nut

  I. Oil sender

  J. Crowfoot

INFORMATION SHEET

VIII. Types of hammers used in the auto shop (Transparency 8)

   A. Ball-peen

   B. Plastic tip

   C. Rubber

   D. Brass

IX. Types of punches (Transparency 9)

   A. Center

   B. Pin

   C. Starting

   D. Drift

   E. Lining-up

X. Types of chisels (Transparency 10)

   A. Cold

   B. Cape

   C. Round nose

   D. Diamond point

XI. Types of files (Transparency 11)

   A. Flat

   B. Half round

   C. Triangle

   D. Round

XII. Types of file teeth (Transparency 12)

   A. Rasp cut

   B. Curved

   C. Single cut

   D. Double cut

INFORMATION SHEET

XIII. Types of parts cleaning tools (Transparency 13)

- A. Wire brush
- B. Carbon scraper
- C. Gasket scraper
- D. Parts cleaning brush

XIV. General shop tools (Transparencies 14, 15, and 16)

- A. Tap and die set
- B. Lug wrench
- C. Hacksaw
- D. Metal cutting shears
- E. Dial indicator set
- F. Snap-ring pliers
- G. Measuring tape
- H. Allen wrench set
- I. Puller set
- J. Torque wrench

  (NOTE: Torque wrenches have two types of scales, inch pound and foot pound.)

XV. Battery service tools (Transparency 17)

- A. Cable puller
- B. Terminal pliers
- C. Post and cable cleaner
- D. Cable spreader
- E. Lifting strap
- F. Battery filler
- G. Hydrometer

INFORMATION SHEET

XVI. Starter service tools (Transparency 18)

- A. Growler
- B. Bushing driver set
- C. Remote control starter switch
- D. Amp-volt tester

XVII. Charging system service tools (Transparency 19)

- A. Amp-volt tester
- B. Ohmmeter
- C. Diode tester
- D. Continuity light

XVIII. Ignition service tools (Transparency 20)

- A. Insulated pliers
- B. Spark plug ratchet and socket
- C. Spark plug gauge
- D. Feeler gauge
- E. Spring gauge
- F. Dwell meter
- G. Timing light

XIX. Fuel system service tools (Transparency 21)

- A. Fuel pump tester
- B. Tube flaring tool
- C. Tube cutter

INFORMATION SHEET

XX. Exhaust system service tools (Transparency 22)

A. Hand pipe cutter

B. Power chisel

C. Pipe expanding tool

D. Straightening cone

E. Chain wrench

F. Electric pipe joint heater

XXI. Cooling system service tools (Transparency 23)

A. Hose clamp pliers

B. Radiator pressure tester

C. Antifreeze tester

D. Belt tension gauge

E. Fan wrench

F. Radiator hose remover tool

XXII. Lubrication service tools (Transparency 24)

A. Grease gun

B. Grease fitting tool

C. Oil can (trigger type)

D. Oil filter removing tools

E. Oil spout

F. PCV tester

G. Transmission filler funnel

XXIII. Brake service tools (Transparency 25)

A. Cylinder hone

B. Cylinder clamp

INFORMATION SHEET

   C. Adjusting tool

   D. Spring pliers

   E. Disc brake pad spreader

   F. Bleeder wrench

   G. Brake shoe adjusting gauge

XXIV. Front-end service tools (Transparency 26)

   A. Toe-in adjusting wrench

   B. Tie-rod end removing tool

   C. Ball joint removing tool

   D. Dust cover remover

   E. Seal driver set

XXV. Engine repair tools (Transparencies 27 and 28)

   A. Ridge reamer

   B. Cylinder deglazing hone

   C. Cylinder taper gauge

   D. Piston ring groove cleaner

   E. Piston ring expander

   F. Piston ring compressor

   G. Valve spring compressor

   H. Valve spring pressure tester

XXVI. Drive line service tools (Transparency 29)

   A. Automatic transmission pressure gauge set

   B. Flywheel turner

   C. Clutch aligning set

INFORMATION SHEET

D. Differential adjusting tool

E. Snap-ring pliers

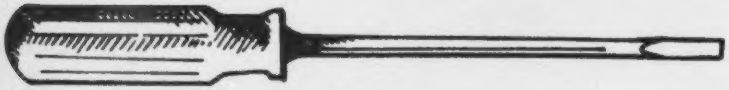
F. Universal joint press set

G. Transmission bushing puller

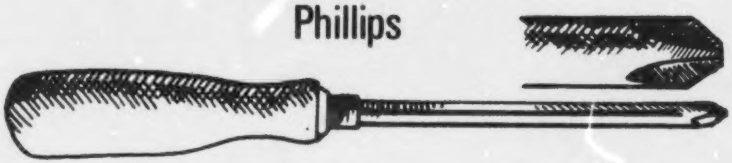
H. Transmission bushing driver

I. Dial indicator

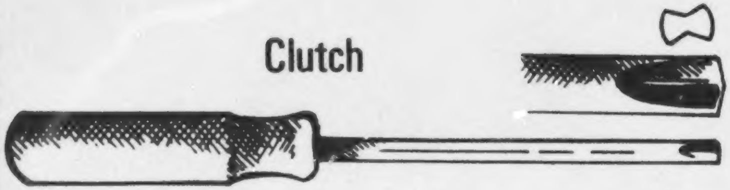
Types of Screwdrivers



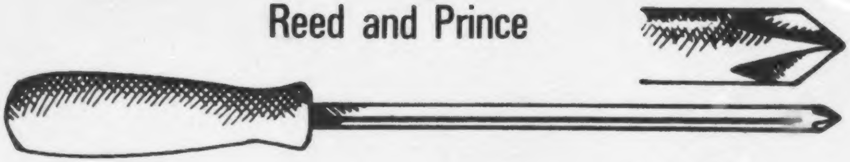
Standard or Common



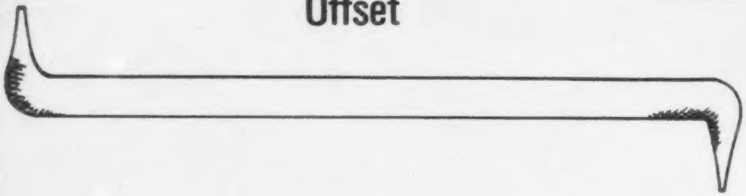
Phillips



Clutch



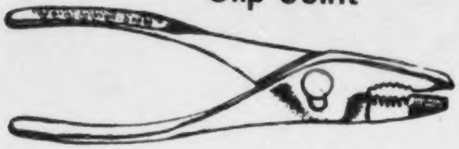
Reed and Prince



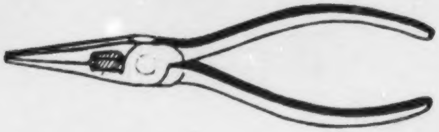
Offset

Types of Pliers

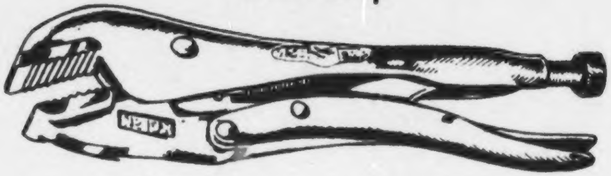
Slip Joint



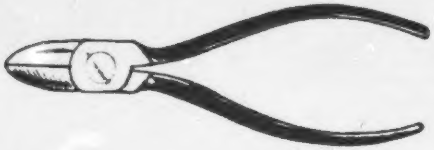
Needle Nose



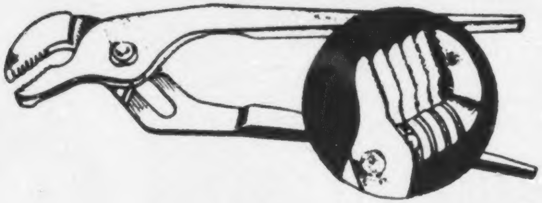
Lock Grip



Diagonal Side Cutter

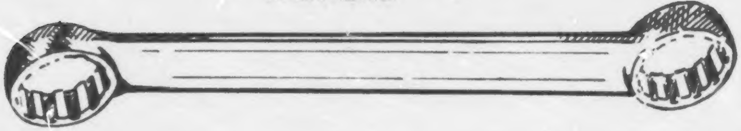


Channel Lock

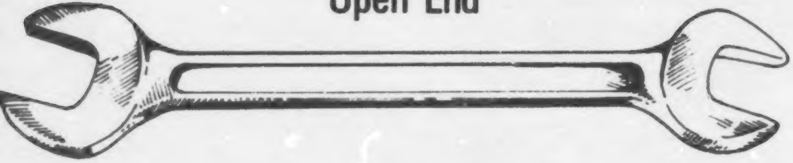


Types of Wrenches

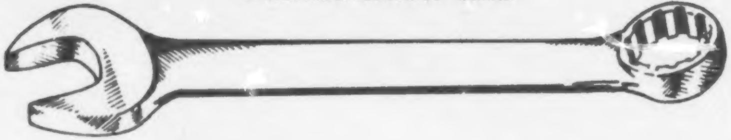
Box End



Open End



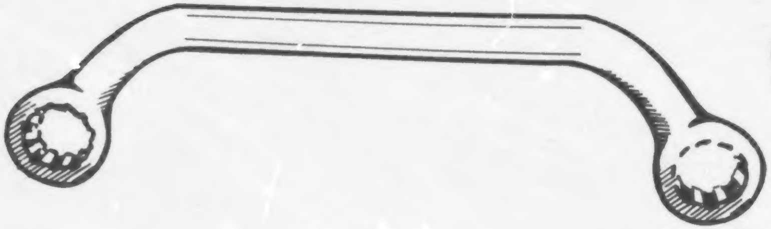
Combination End



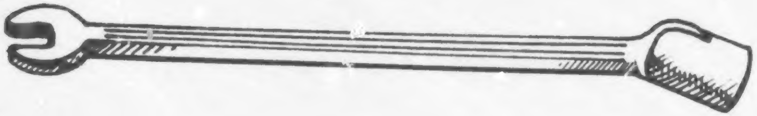
Types of Wrenches

(Continued)

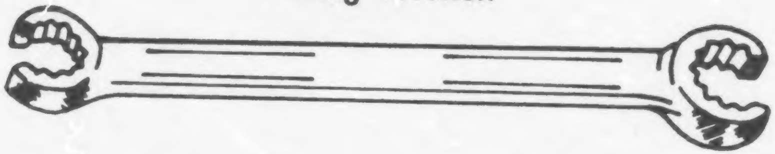
Obstruction Box End



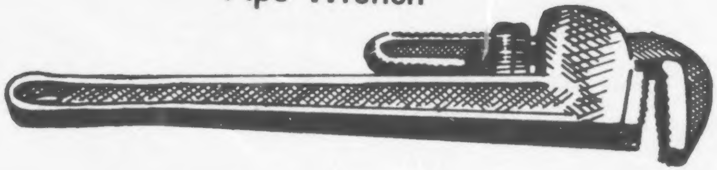
Flex Head



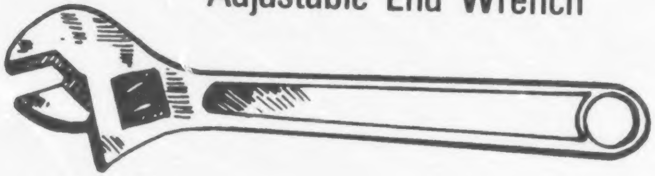
Tubing Wrench



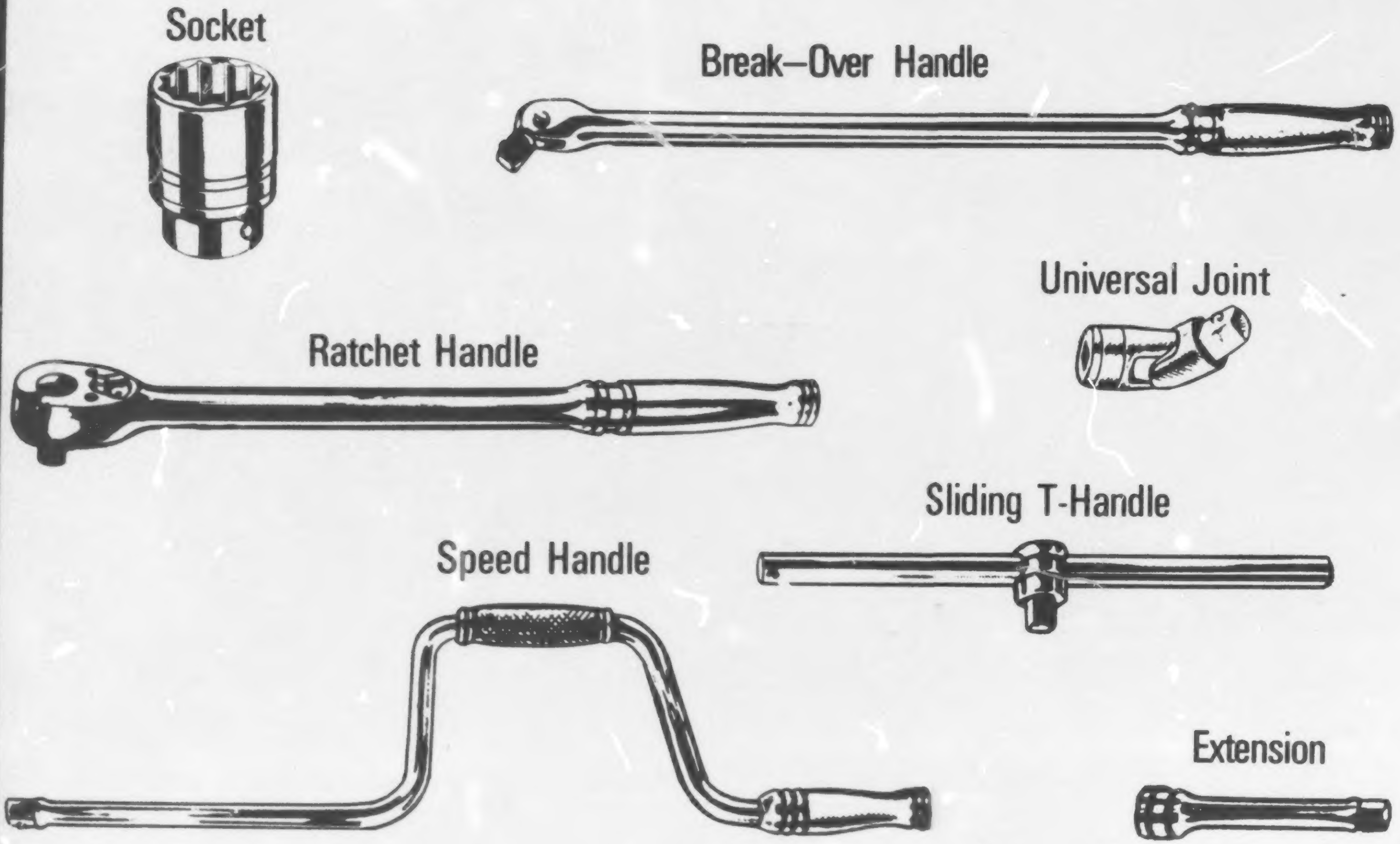
Pipe Wrench



Adjustable End Wrench

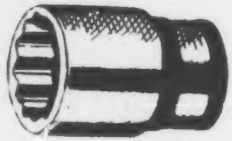


Components of a Socket Set

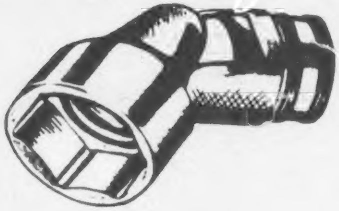

Socket
Break–Over Handle
Universal Joint
Ratchet Handle
Sliding T-Handle
Speed Handle
Extension

Types of Sockets

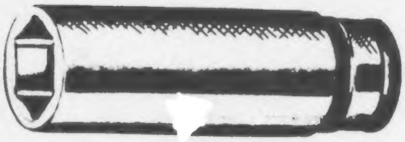
Standard



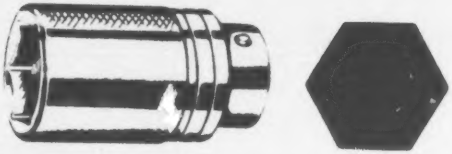
Universal



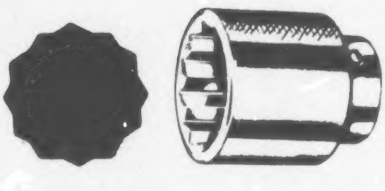
Deep Well



Six Point

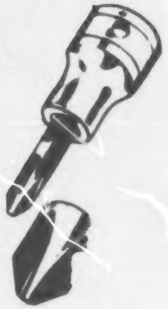


Twelve Point

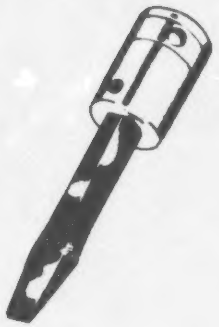


Special Purpose Sockets

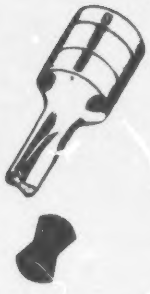
Phillips



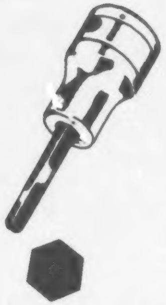
Standard



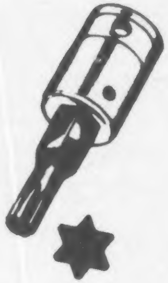
Clutch



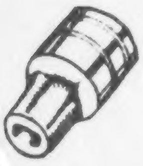
Allen or Hex Head



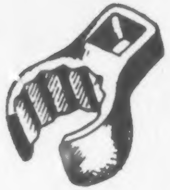
Triple
Square Cap



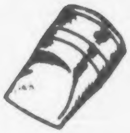
Shock Absorber



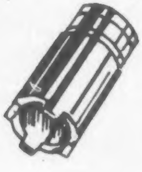
Crowfoot



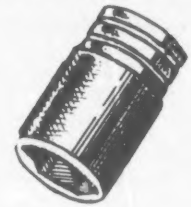
Drag Link



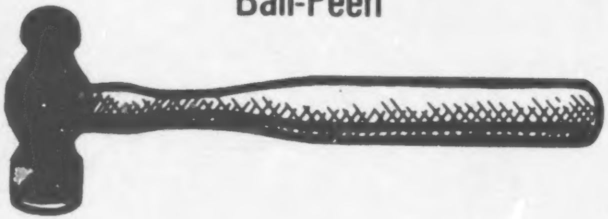
Prong Nut or Dash Nut

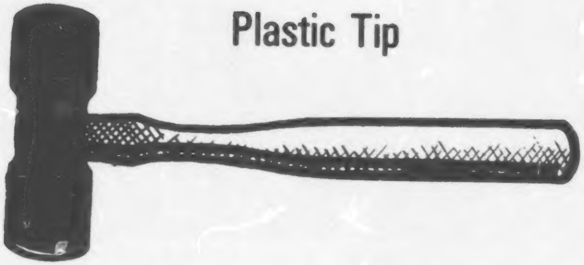


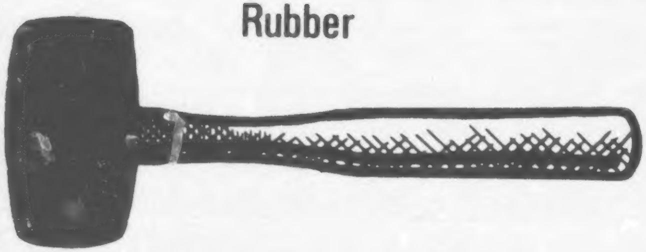
Oil Sender

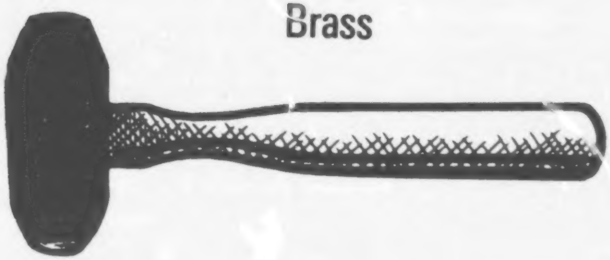


Types of Hammers


Ball-Peen

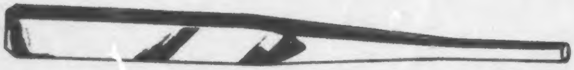

Plastic Tip


Rubber

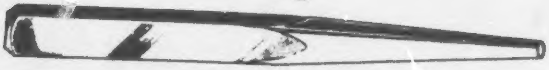

Brass

Types of Punches

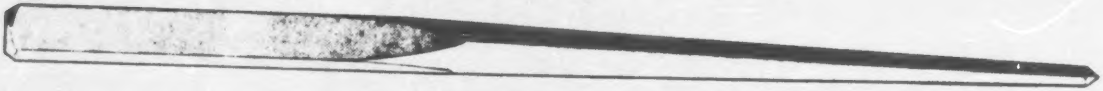
Pin



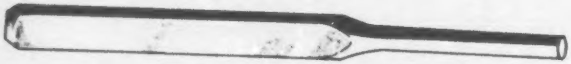
Starting



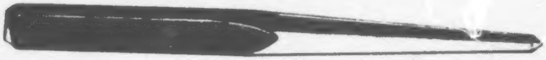
Lining-Up



Drift

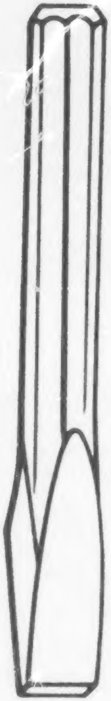


Center

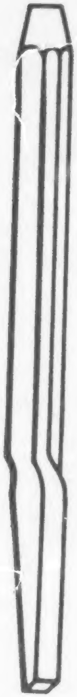


Types of Chisels

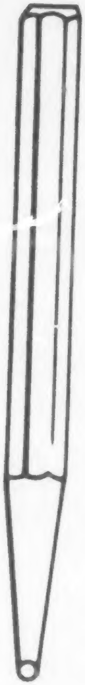
Cold



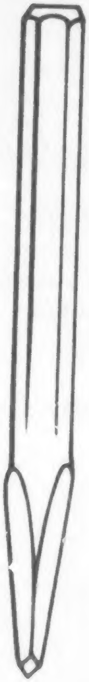
Cape



Round Nose

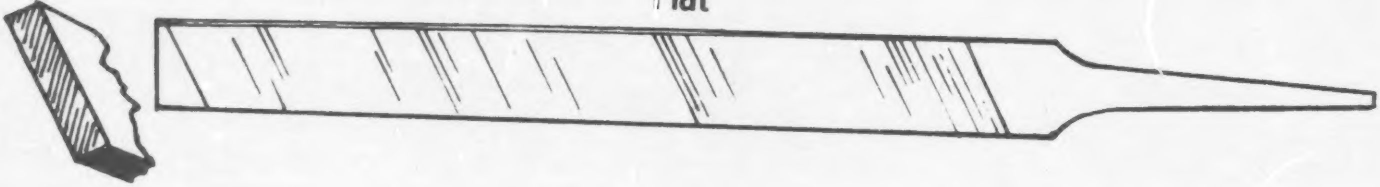


Diamond Point

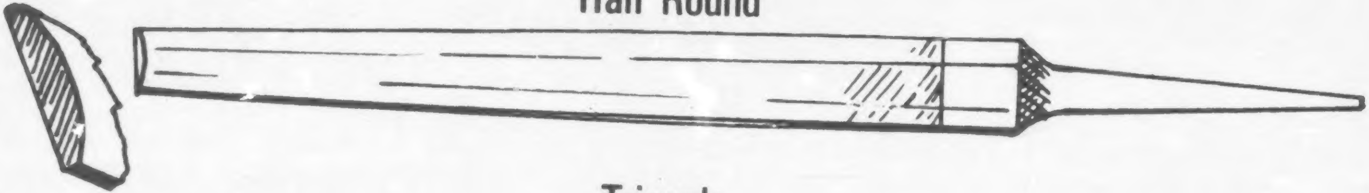


Types of Files

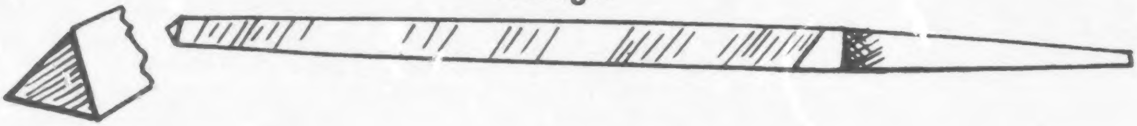
Flat



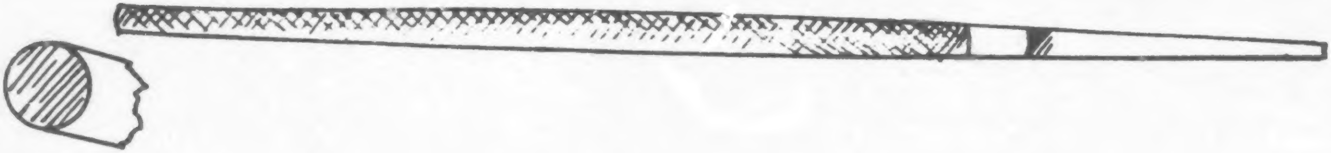
Half Round



Triangle

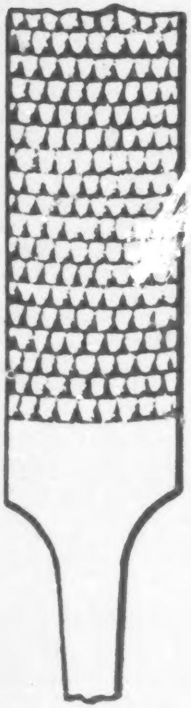


Round

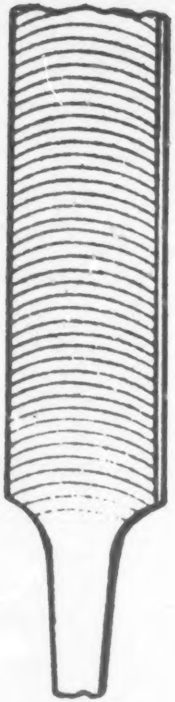


Types of File Teeth

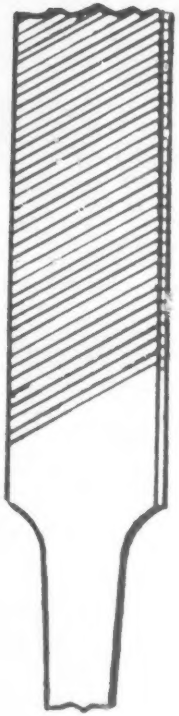
Rasp Cut



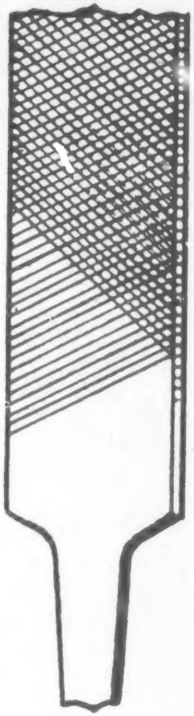
Curved



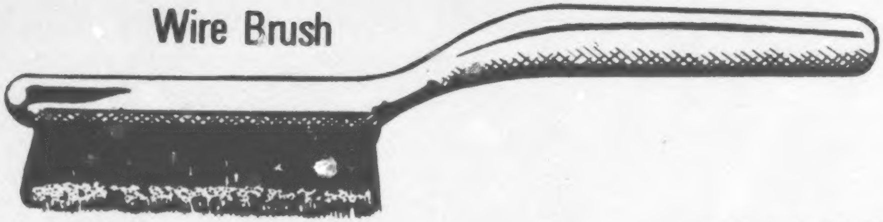
Single Cut



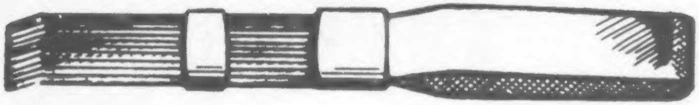
Double Cut



Types of Parts Cleaning Tools

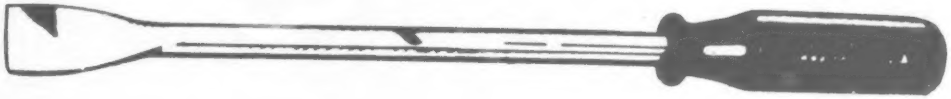


Wire Brush



Carbon Scraper

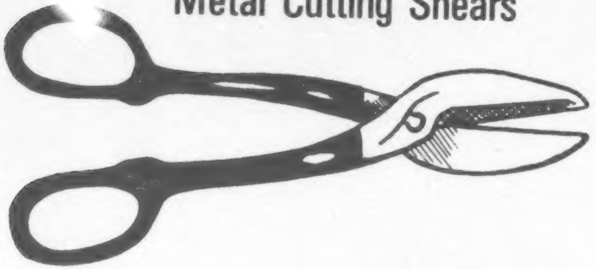
Parts Cleaning Brush



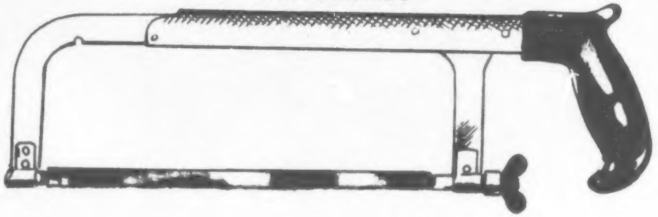
Gasket Scraper

General Shop Tools

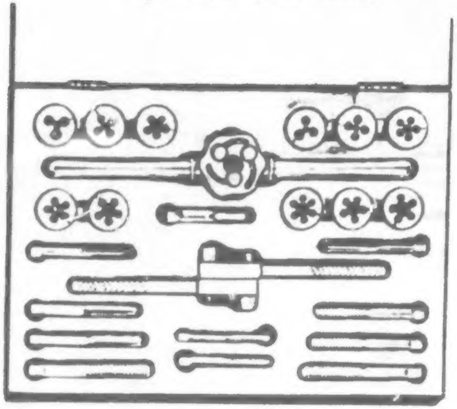
Metal Cutting Shears



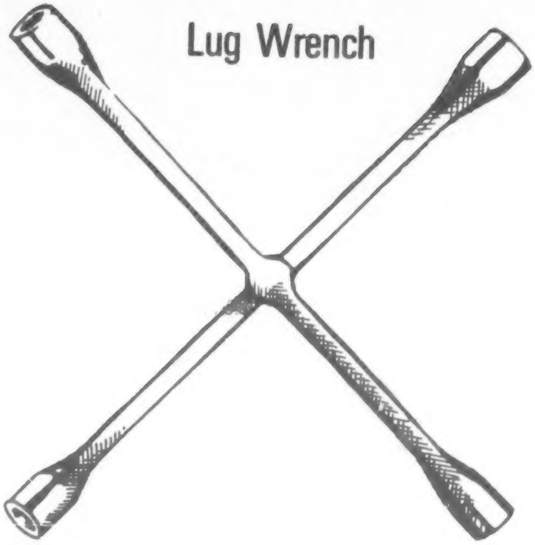
Hacksaw



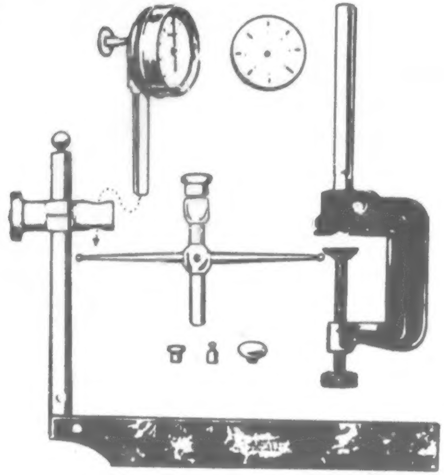
Tap and Die Set



Lug Wrench



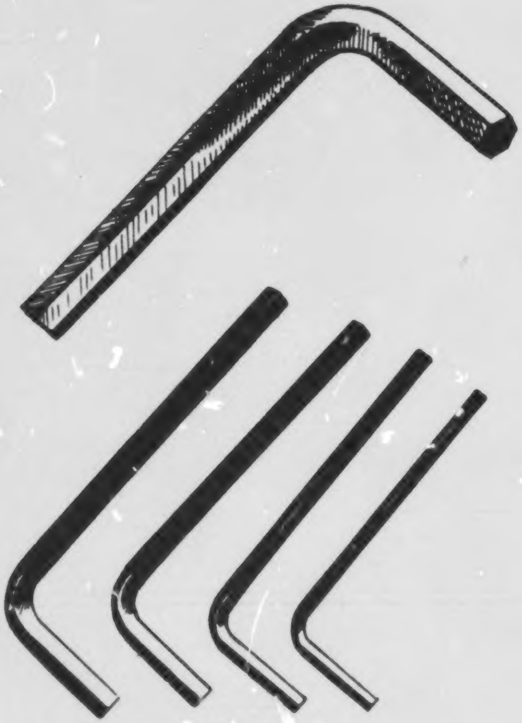
Dial Indicator Set



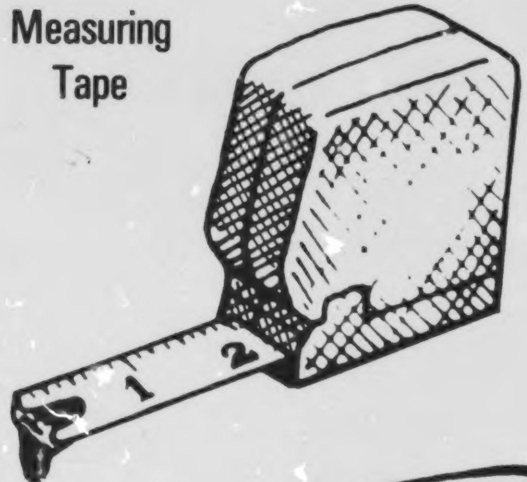
General Shop Tools

(Continued)

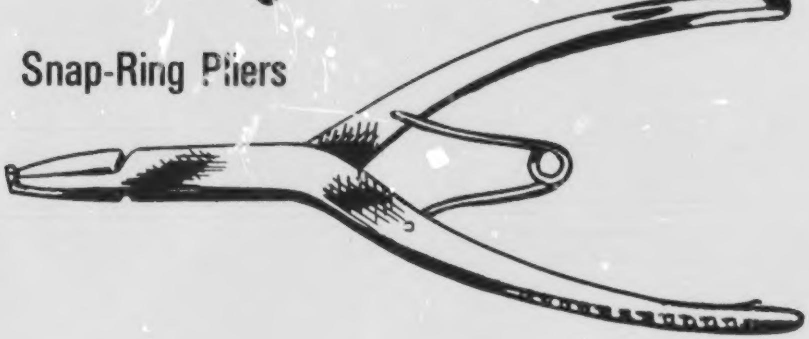
Allen Wrench Set



Measuring Tape



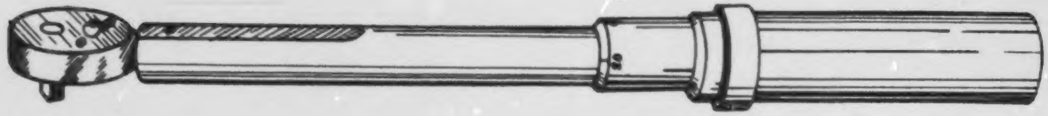
Snap-Ring Pliers



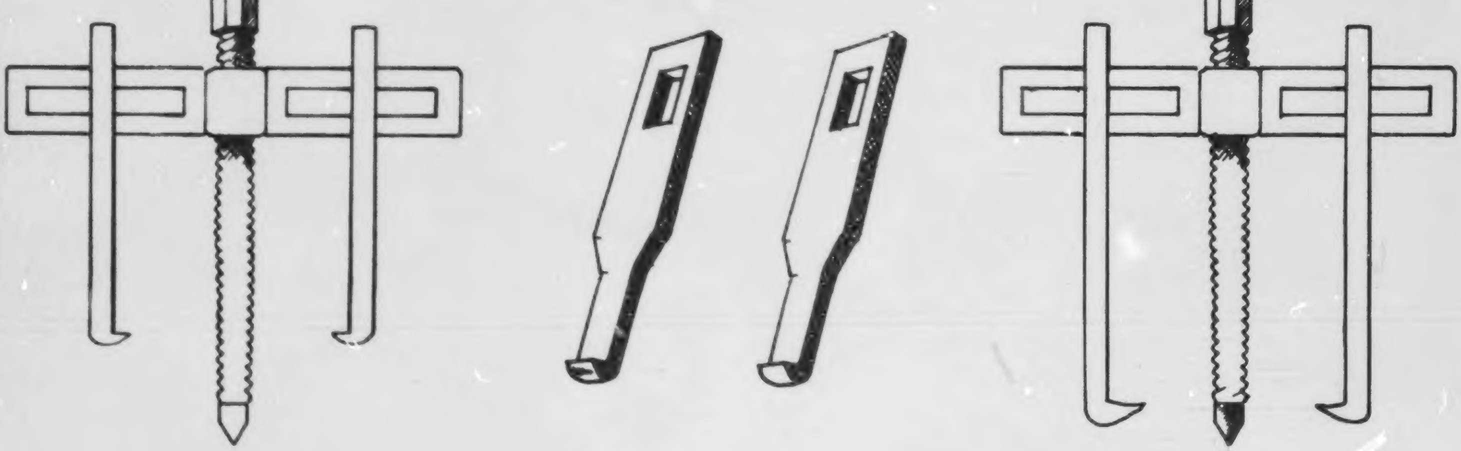
General Shop Tools

(Continued)

Torque Wrench

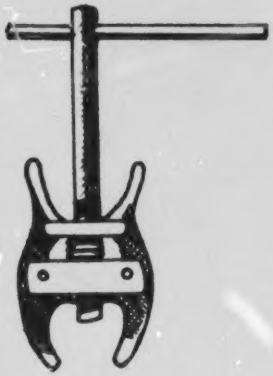


Puller Set

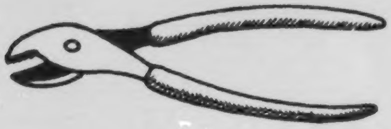


Battery Service Tools

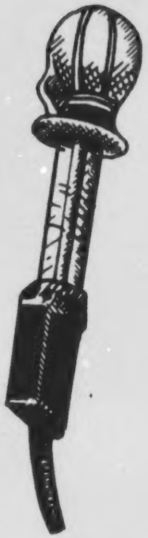
Cable Puller



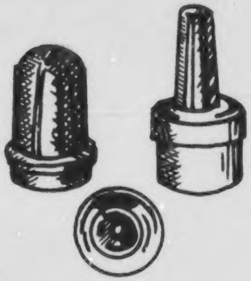
Terminal Pliers



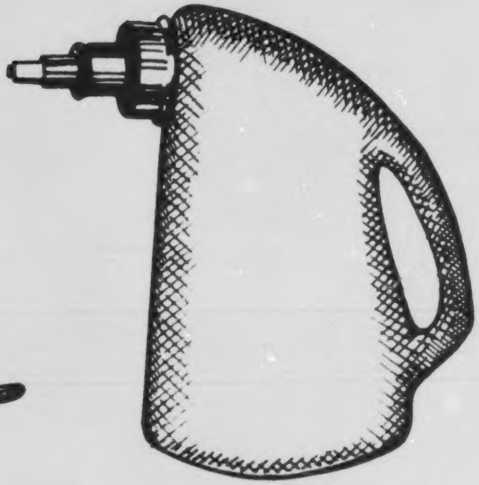
Hydrometer



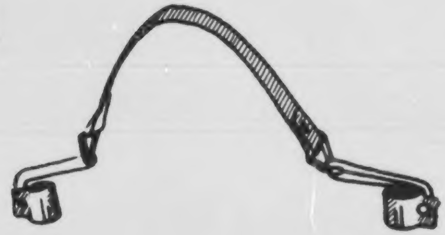
Post and
Cable Cleaner



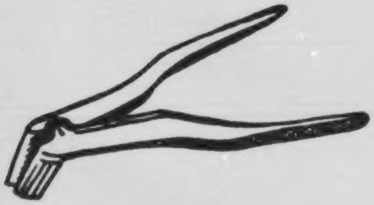
Battery Filler



Lifting strap

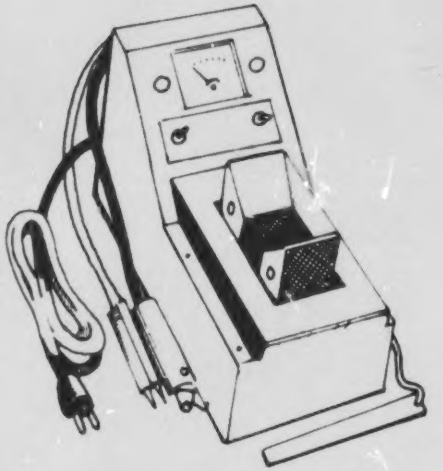


Cable Spreader

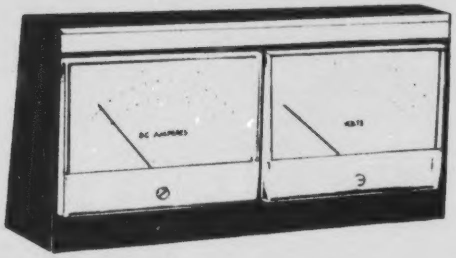


Starter Service Tools

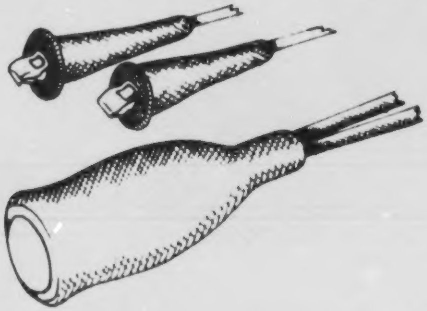
Growler



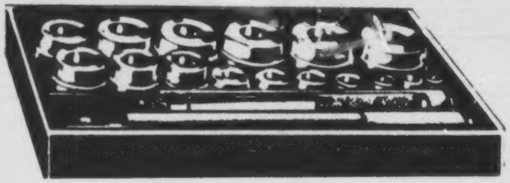
Amp–Volt Tester


DC AMPERES
VOLTS

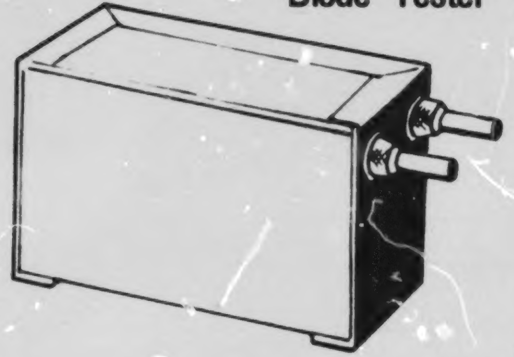
Remote Control Starter Switch

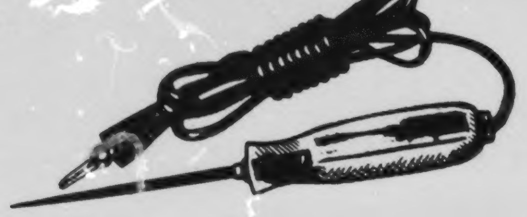


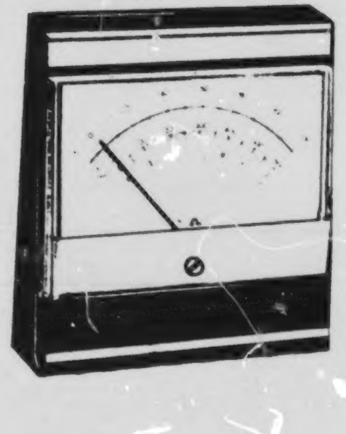
Bushing Driver Set

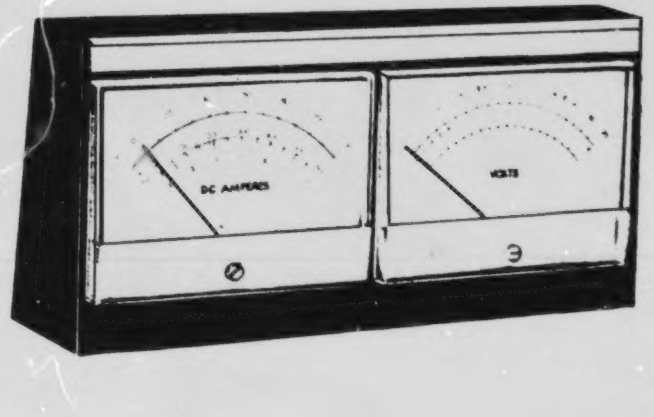


Charging System Service Tools

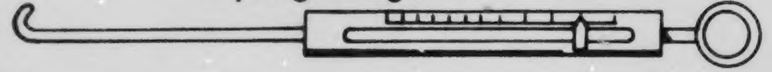

Diode Tester

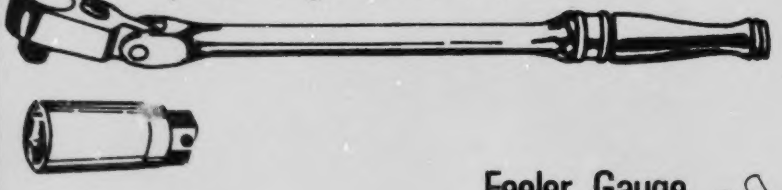

Continuity Light

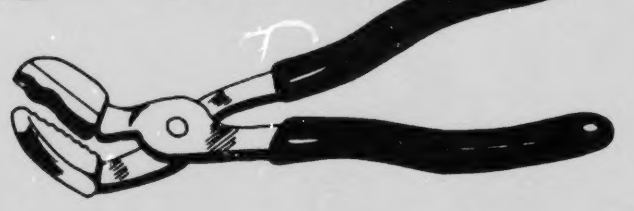

Ohmmeter

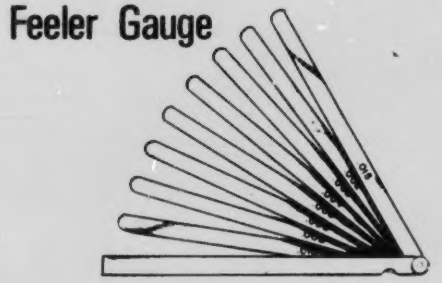

Amp–Volt Tester

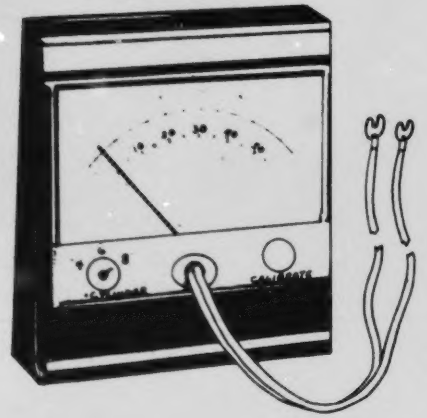
Ignition Service Tools

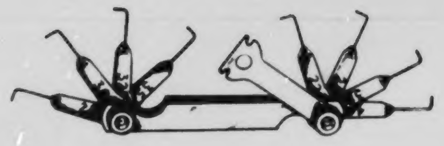

Spring Gauge

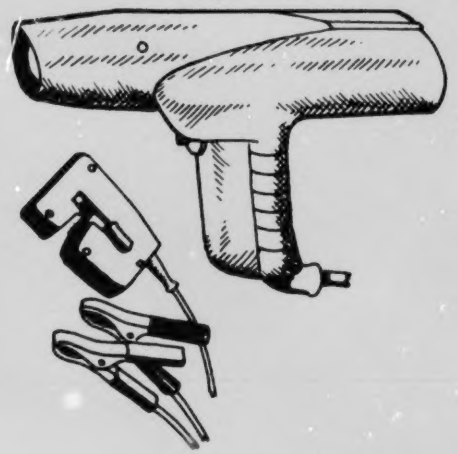

Spark Plug Ratchet and Socket


Insulated Pliers

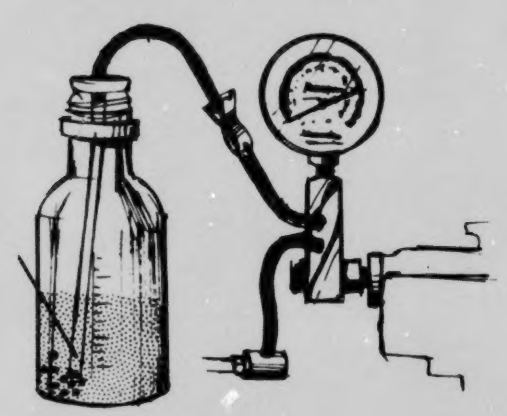

Feeler Gauge

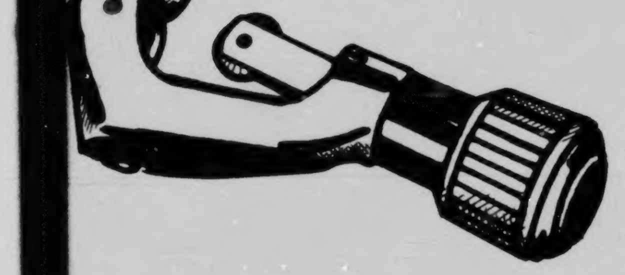

Dwell Meter

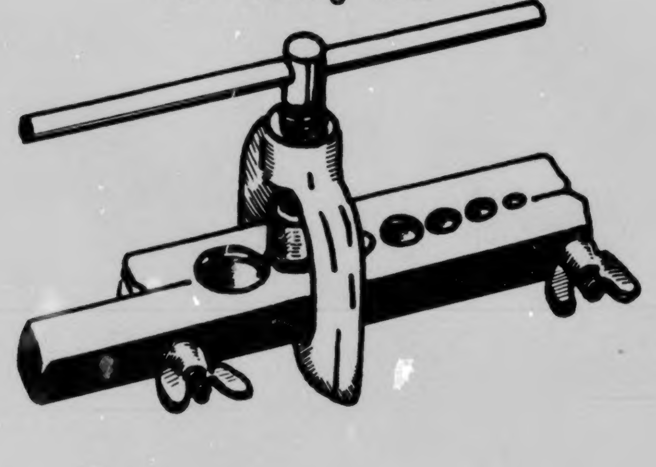

Spark Plug Gauge


Timing Light

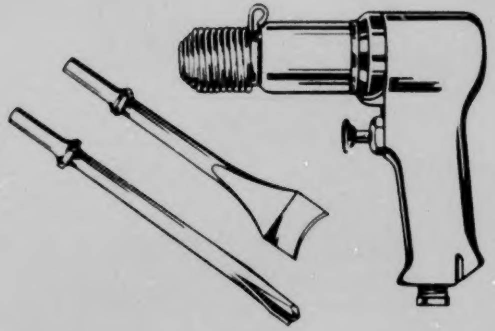
Fuel System Service Tools


Fuel Pump Tester

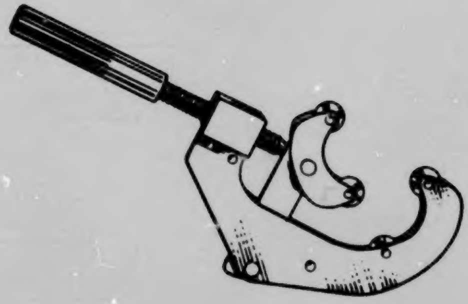

Tube Cutter


Tube Flairing Tool

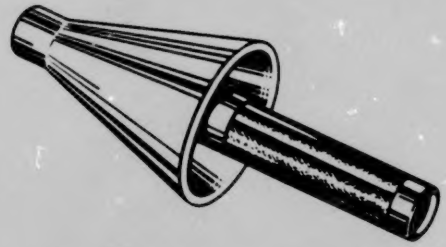
Exhaust System Service Tools



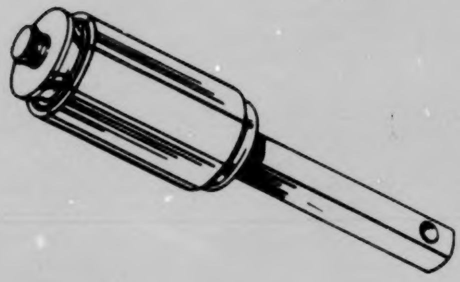
Power Chisel



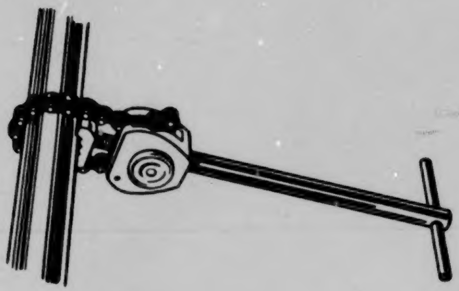
Hand Pipe Cutter



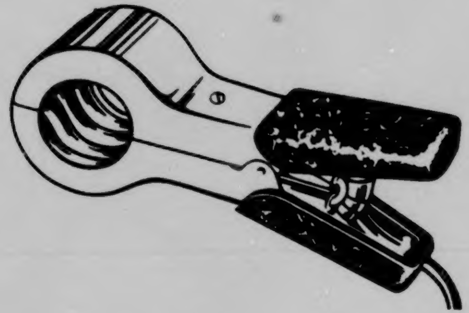
Straightening Cone



Pipe Expanding Tool

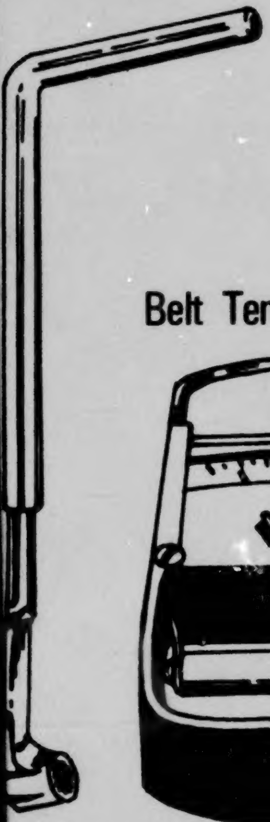


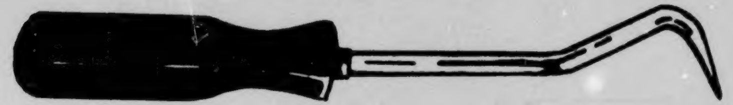
Chain Wrench

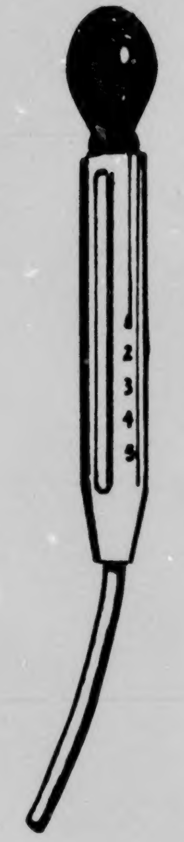


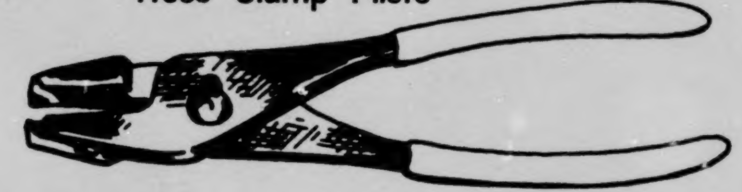
Electric Pipe Joint Heater

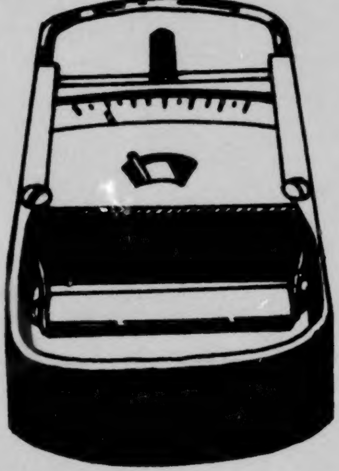
Cooling System Service Tools

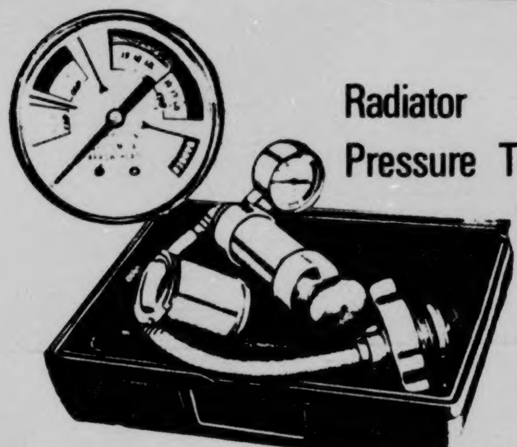

Fan Wrench


Radiator Hose Remover Tool


Antifreeze Tester


Hose Clamp Pliers

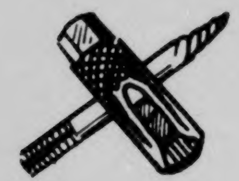

Belt Tension Gauge


Radiator Pressure Tester

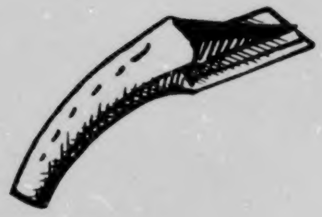
AMT-119-A

Lubrication Service Tools

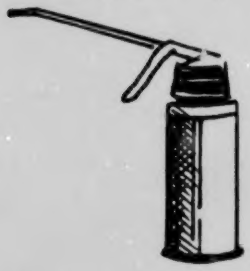
Grease Fitting Tool



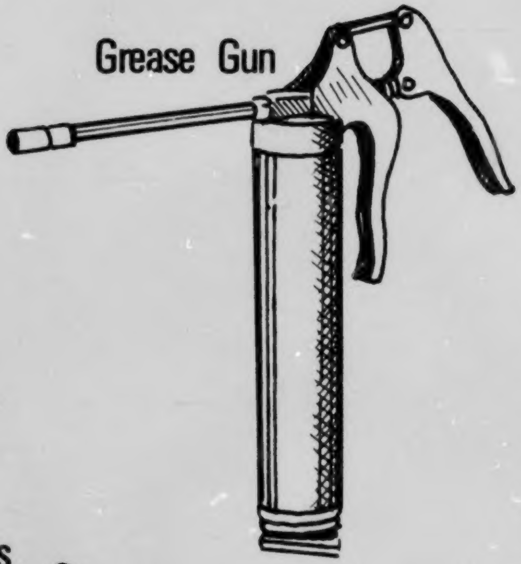
Oil Spout



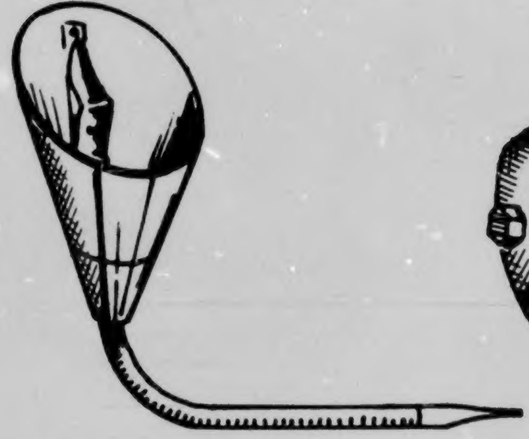
Oil Can
(trigger type)



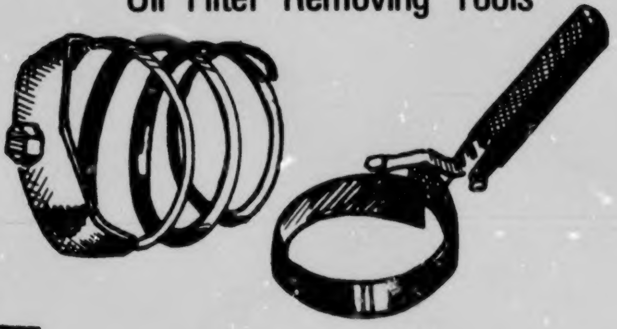
Grease Gun



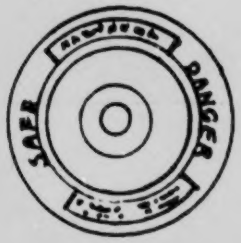
Transmission Filler Funnel



Oil Filter Removing Tools

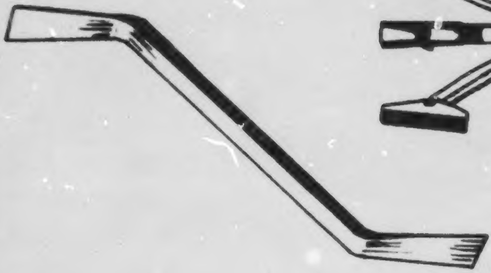


PCV Tester

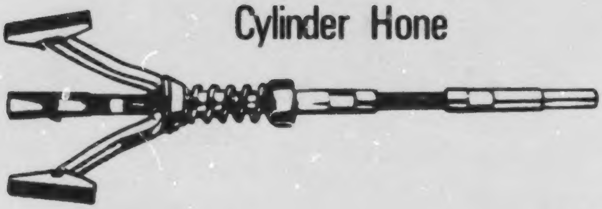


Brake Service Tools

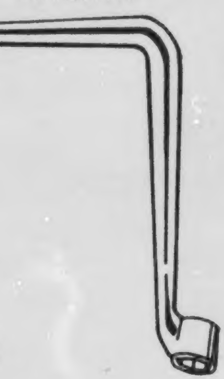
Adjusting Tool



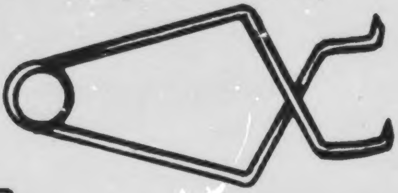
Cylinder Hone



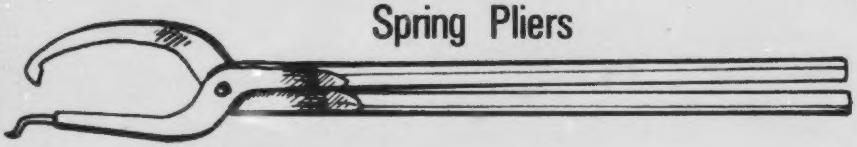
Bleeder Wrench



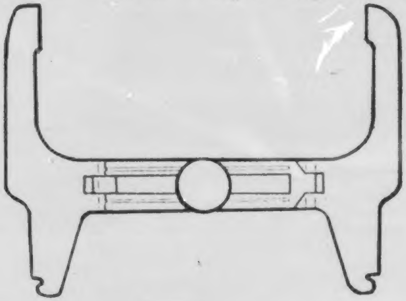
Cylinder Clamp



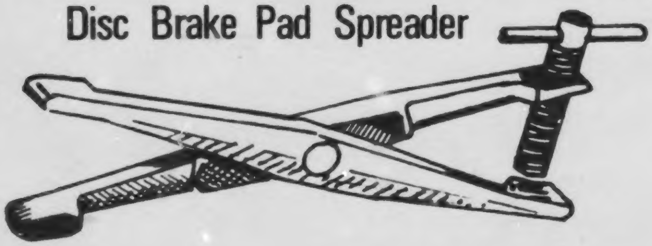
Spring Pliers



Brake Shoe Adjusting Gauge

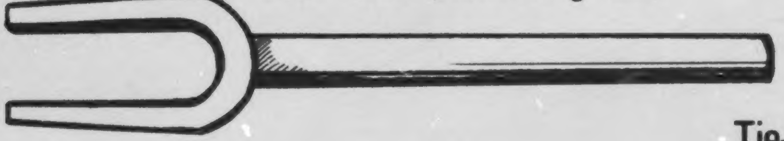


Disc Brake Pad Spreader

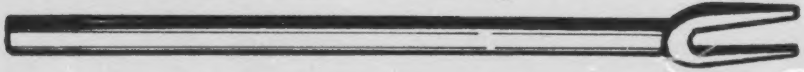


Front-End Service Tools

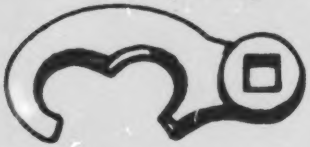
Ball Joint Removing Tool



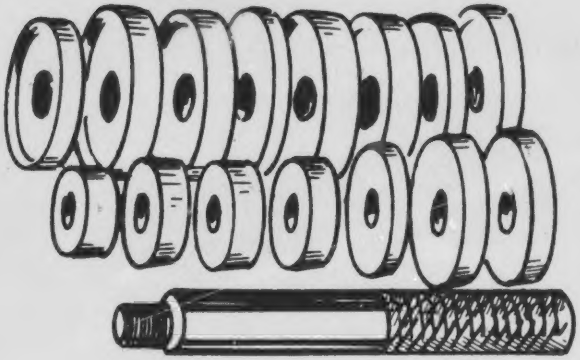
Tie–Rod End Removing Tool



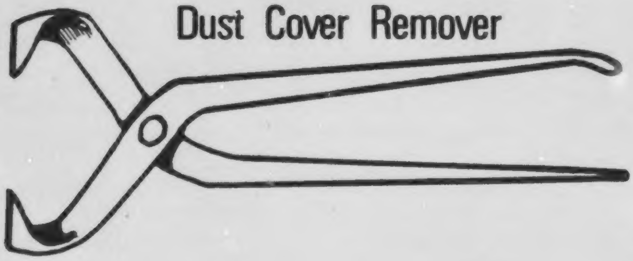
Toe-–In Adjusting Wrench



Seal Driver Set

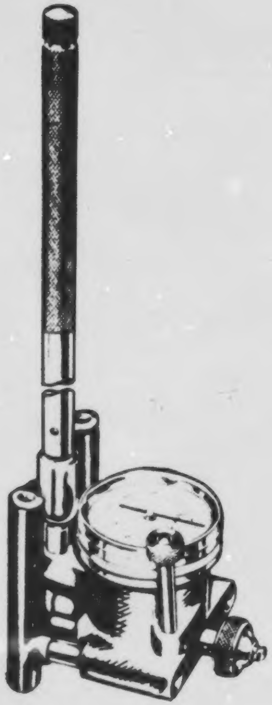


Dust Cover Remover

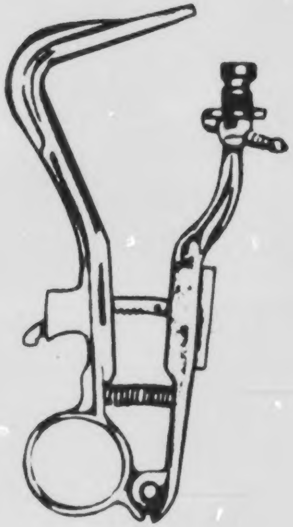


Engine Repair Tools

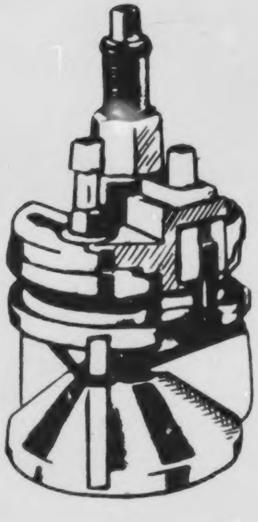
Cylinder Taper Gauge



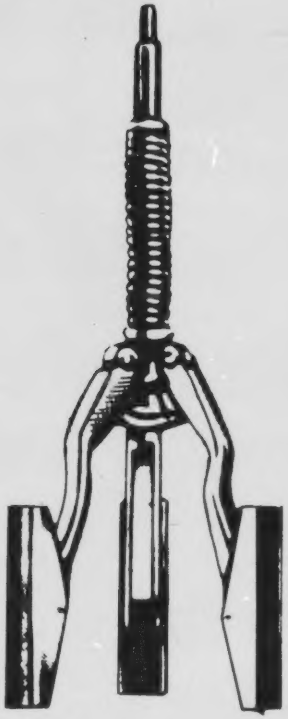
Piston Ring
Groove Cleaner



Ridge Reamer

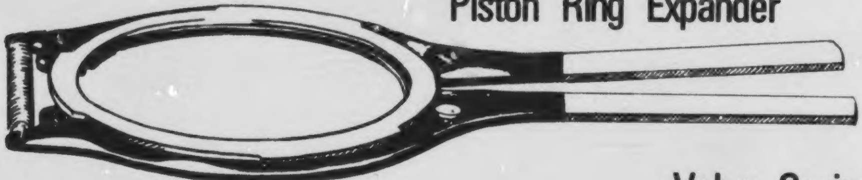


Cylinder Deglazing Hone

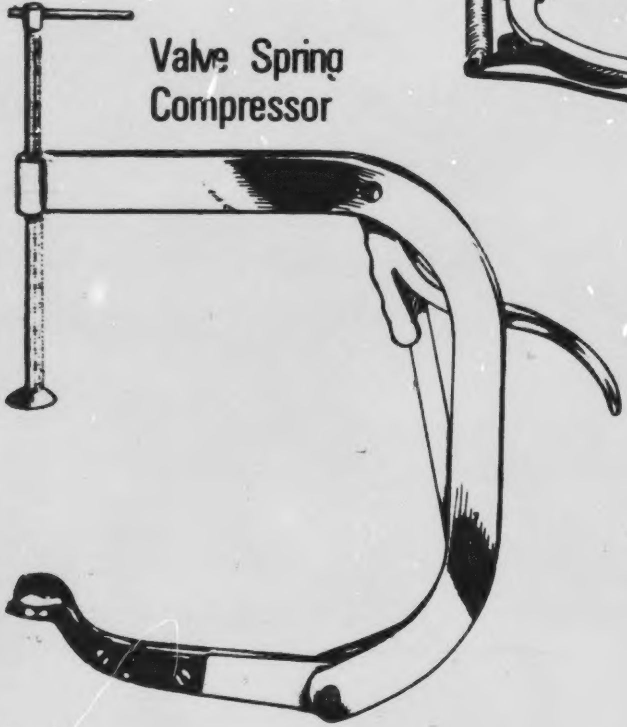


Engine Repair Tools

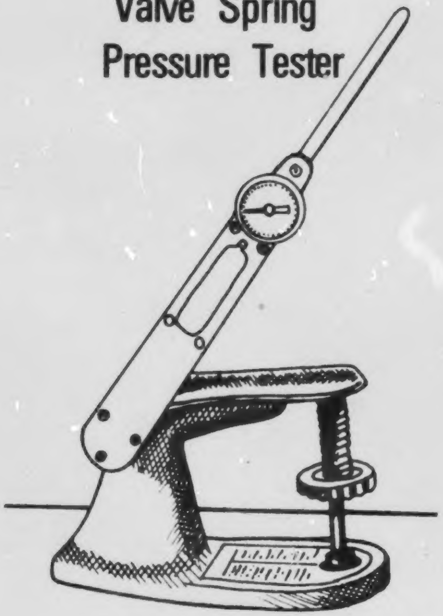
(Continued)



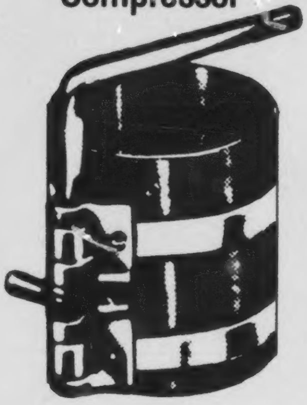
Piston Ring Expander



Valve Spring Compressor

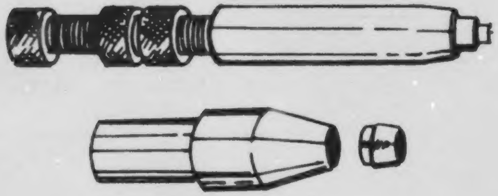


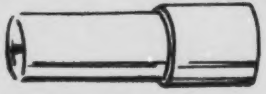
Valve Spring Pressure Tester

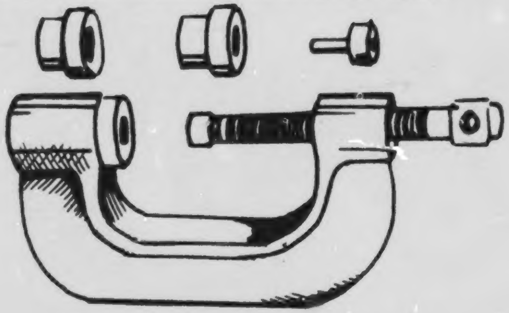


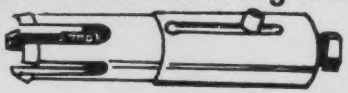
Piston Ring Compressor

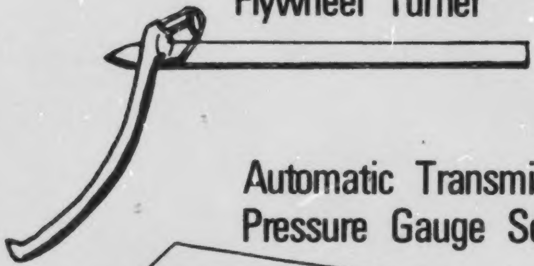
Drive Line Tools

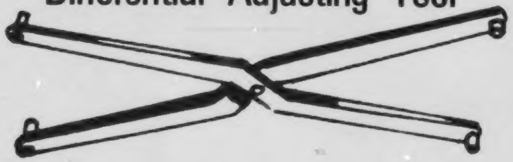

Clutch Aligning Set

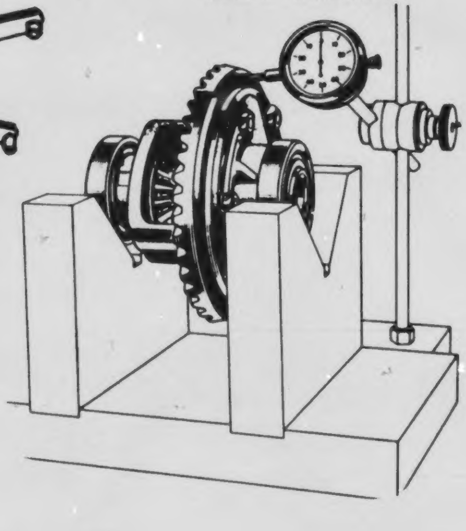

Transmission Bushing Driver

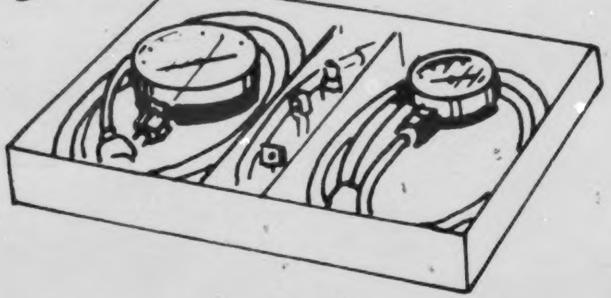

Universal Joint Press Set

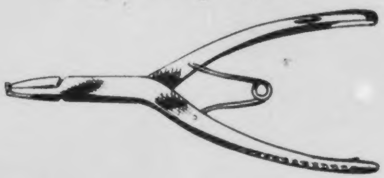

Transmission Bushing Puller


Flywheel Turner


Differential Adjusting Tool


Dial Indicator


Automatic Transmission Pressure Gauge Set


Snap–Ring Pliers

HAND TOOLS
UNIT III

JOB SHEET #1--SHARPEN A TWIST DRILL

I. Tools and equipment

   A. Grinder

   B. Twist drill

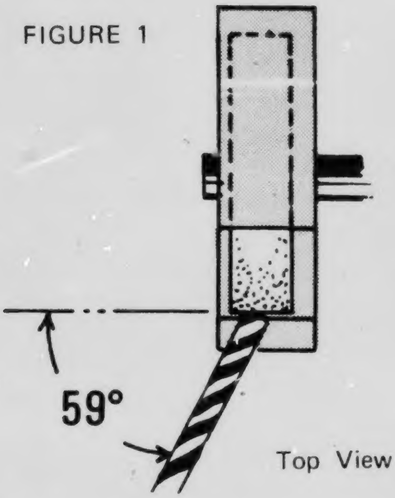
   C. Container of water

   D. Full face shield

II. Procedure

   A. Place the drill point against the grinding wheel at approximately a 59° angle (Figure 1)

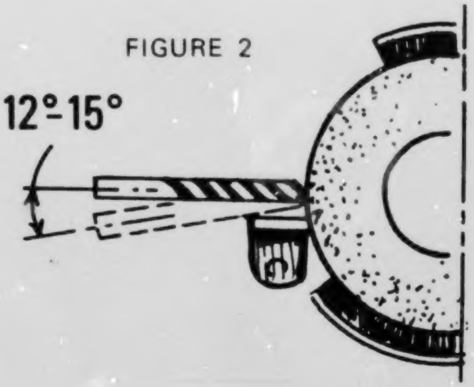
FIGURE 1



JOB SHEET #1

B. Lower the shank and raise the cutting point of the bit against the wheel using both hands (Figure 2)

FIGURE 2



Side View

C. Rotate the bit in a clockwise manner while grinding

(NOTE: Dip the point in water frequently to keep it cool.)

D. Grind both lips in the same manner

HAND TOOLS
UNIT III

JOB SHEET #2--DRILL HOLES WITH A DRILL PRESS

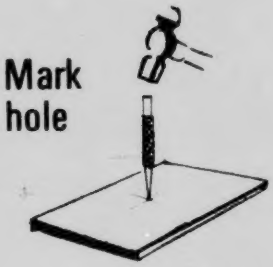
I. Tools and equipment

- A. Small piece of flat metal
- B. Drill press
- C. Center punch
- D. Hammer
- E. Wooden block
- F. Cutting oil
- G. C-clamp
- H. Safety goggles

II. Procedure

A. Mark the hole with a center punch (Figure 1)

FIGURE 1

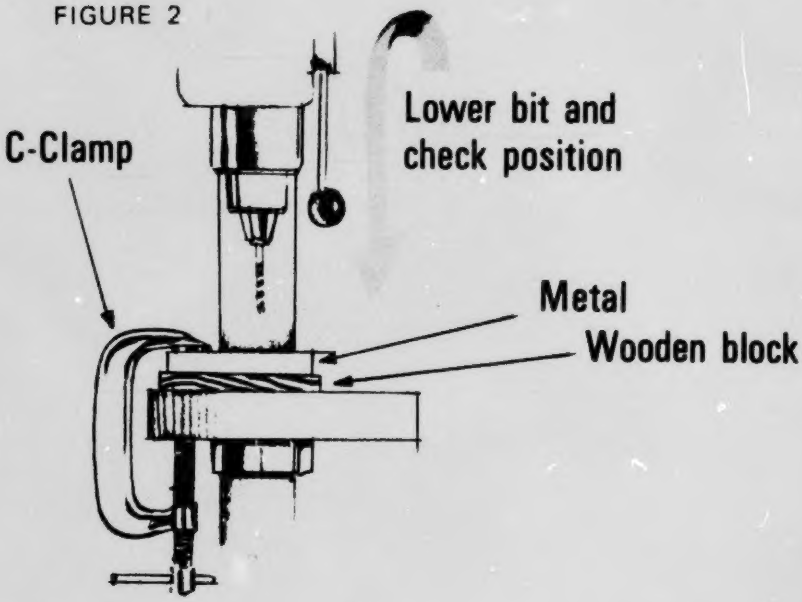


B. Place the metal on a wooden block

JOB SHEET #2

C. Clamp the metal securely to prevent it from spinning (Figure 2)

FIGURE 2


C-Clamp
Lower bit and check position
Metal
Wooden block

D. Feed the bit down to the metal and start drilling

E. Raise the bit to see if you are drilling in the proper place

F. Continue drilling, using cutting oil on the drill bit two or three inches above the work

HAND TOOLS
UNIT III

JOB SHEET #3--RESHAPE A COLD CHISEL

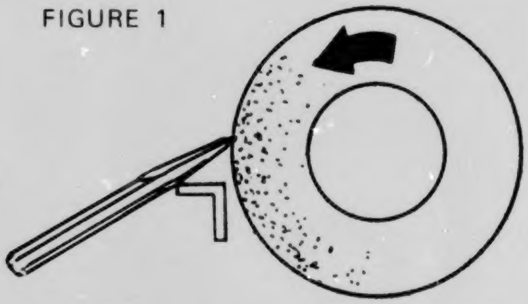
I. Tools and materials

- A. Cold chisel
- B. Grinder
- C. Container of water
- D. Full face shield

II. Procedure

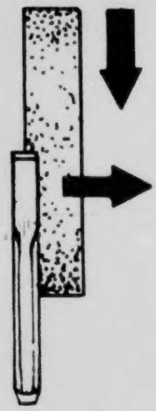
A. Hold the chisel at a 65° to 70° angle with the handle pointing down (Figure 1)

FIGURE 1



B. Move the point from side to side across the grinding wheel (Figure 2)

FIGURE 2

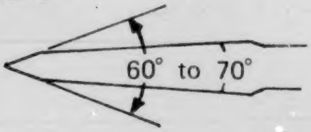


(NOTE: Dip the point in water frequently to keep it cool.)

JOB SHEET #3

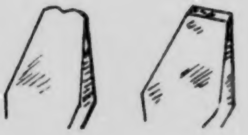
C. Grind both sides of the cutting edge in the same manner (Figure 3)

FIGURE 3



D. Grind the head back into shape if it has become mushroomed (Figure 4)

FIGURE 4



HAND TOOLS
UNIT III

JOB SHEET #4--CUT FLAT METAL WITH A COLD CHISEL

I. Tools and equipment

   A. Marker (oval or chalk)

   B. Flat strip of metal

   C. Chisel

   D. Hammer

   E. Vise

   F. Full face shield

II. Procedure

   A. Mark the metal

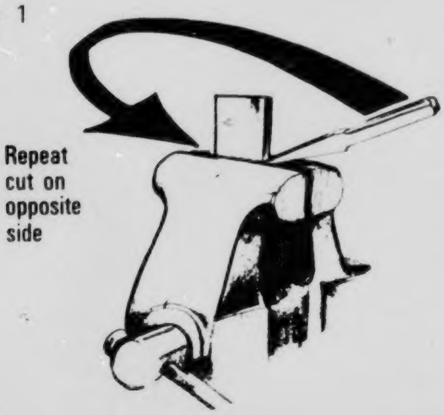
   B. Place the metal in the vise with the cutting mark just above the jaws of the vise

   C. Select proper size chisel and hammer

   (NOTE: For larger size metal, use a larger chisel and hammer.)

   D. Place the chisel at side of the metal to start the shearing point (Figure 1)

FIGURE 1



JOB SHEET #4

E. Hold the chisel at approximately a 60° angle

F. Make cuts from each end of the metal to the center and on both sides

(NOTE: Drive the chisel with a hammer.)

G. Bend metal back and forth until it breaks

HAND TOOLS
UNIT III

JOB SHEET #5--DRESS A GRINDING WHEEL

I. Tools and equipment

  A. Grinding wheel

  B. Dressing tool

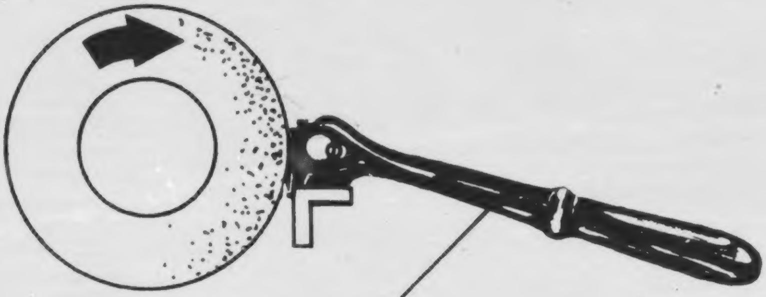
  C. Full face shield

II. Procedure

  A. Select the proper dressing tool

  B. Set the dressing tool on the grinder tool rest and press it firmly against the wheel (Figure 1)

FIGURE 1



(NOTE: Use enough pressure on the tool to prevent sparks.)

  C. Dress the grinder wheel with the tool until the edges are square with the sides

HAND TOOLS
UNIT III

JOB SHEET #6--FIT A SCREWDRIVER

I. Tools and equipment

   A. Grinder

   B. Screwdriver

   C. Screw with head size equal to the width of the screwdriver blade

   D. Container of water

   E. Full face shield

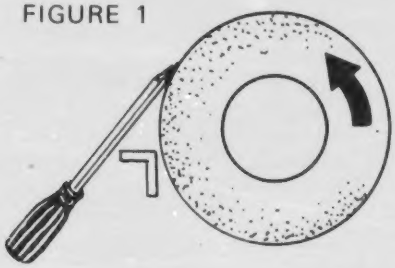
II. Procedure

   A. Place screwdriver against the grinder wheel at a 90° angle to square the tip

   B. Apply light pressure on blade while grinding

   C. Shape both faces of screwdriver (Figure 1)

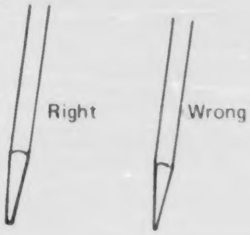
FIGURE 1



   D. Use screw head to determine the extent of grinding desired

   (NOTE: Do not round or sharpen the end. See Figure 2.)

FIGURE 2



   E. Dip point in water frequently to keep it cool

HAND TOOLS
UNIT III

JOB SHEET #7--REPLACE A HAMMER HANDLE

I. Tools and equipment

   A. Hammer with a broken handle

   B. Hacksaw

   C. Twist drill

   D. Punch

   E. Rasp

   F. Handsaw

   G. Soft-faced hammer

   H. Vise

   (NOTE: Cover the jaws of the vise with sheet metal or use wood blocks to prevent damage to the hammer and handle.)

   I. New handle

   J. Small piece of wood for wedge

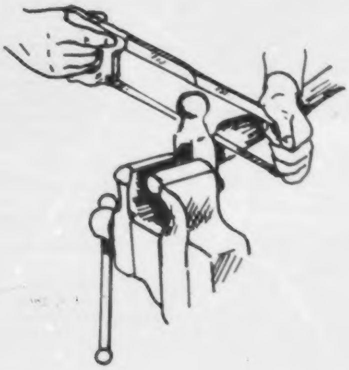
   K. Safety glasses

II. Procedure

   A. Place the hammer head in the vise

   B. Saw the broken handle close to the hammer head with a hacksaw (Figure 1)

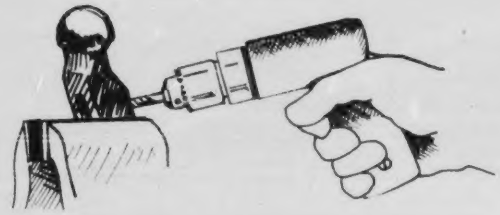
FIGURE 1



JOB SHEET #7

C. Remove the wood from the eye by first drilling with a twist drill and then punching out the remainder (Figure 2)

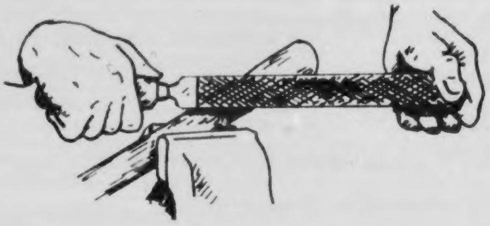
FIGURE 2



D. Place the new handle in the vise

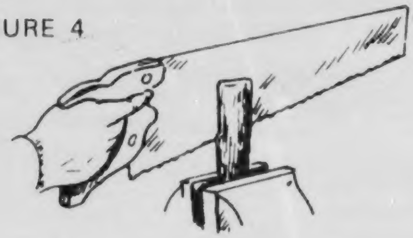
E. Work the new handle down to size with a rasp, trying the handle in the head frequently (Figure 3)

FIGURE 3



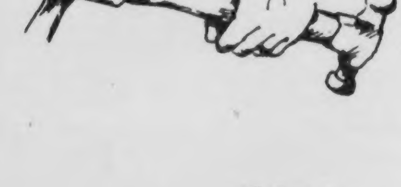
F. Make a cut across the long diameter of the top of the handle to a distance of about 2/3 the depth of the eye using the handsaw (Figure 4)

FIGURE 4



G. Drive the handle firmly into place using a soft-faced hammer (Figure 5)

FIGURE 5



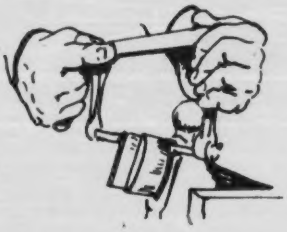
JOB SHEET #7

H. Make a thin metal wedge and drive it tightly into the cut in the end of the handle

I. Place the hammer in the vise and use a hacksaw to cut off the handle and wedge extending through the head (Figure 6)

(NOTE: If steel wedges are used, the end of the handle need not be cut across the diameter because the wedge can be driven into place after the handle has been cut off even with the head.)

FIGURE 6



HAND TOOLS
UNIT III

JOB SHEET #8--CHECK TORQUE WRENCH FOR ACCURACY

I. Tools and materials

A. Torque wrench

B. Vise

C. "Known" weight

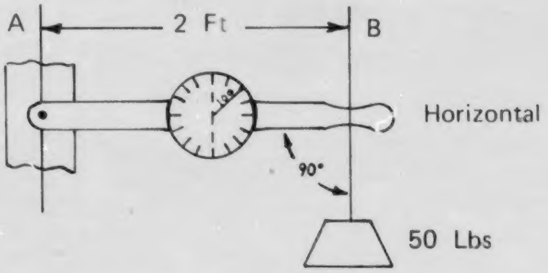
(NOTE: Weight should be at least one-third the capacity of the torque wrench.)

D. Strong cord

II. Procedure

A. Hang torque wrench on a fixed nut or secure in a vise (Figure 1)

FIGURE 1



A = Center Line of Nut   B = Point of Suspension

B. Set the indicator to "0"

C. Hang a known weight from the wrench handle at any known distance from the center of the nut (Figure 1)

D. Multiply the weight times the distance from A to B (Figure 1)

E. Compare the answer to the indicator reading

(NOTE: Using the example in Figure 1, 50 pounds x 2 feet = 100 foot pounds.)

HAND TOOLS
UNIT III

JOB SHEET #9--DRAW FILE A FLAT SURFACE

I. Tools and materials

  A. File handle

  B. Machinist's file

  (NOTE: A machinist's file has double cut teeth for cutting in both directions.)

  C. Vise

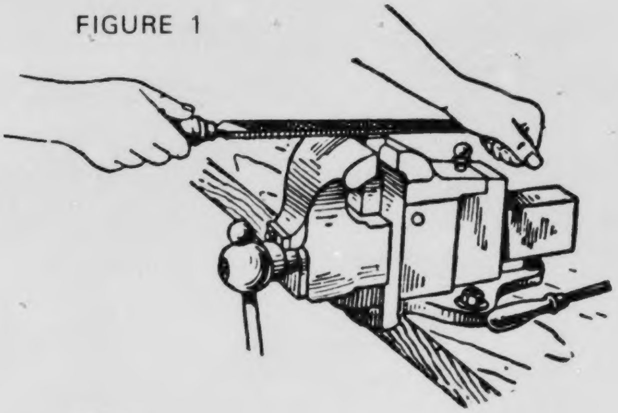
  D. Cylinder head or stock to be draw filed

II. Procedure

  A. Secure stock

    1. Secure cylinder head on suitable stand or fixture (Figure 1)

FIGURE 1



    2. Secure smaller stock in vise

  B. Equip file with a tight-fitting handle

  C. Draw the file crosswise over the work with a light pressure

  D. Apply enough pressure to keep file cutting in both directions

HAND TOOLS
UNIT III

JOB SHEET #10--DRAW A TWIST DRILL HOLE TO CORRECT CENTER

I. Tools and materials

   A. Electric drill, 1/2" chuck

   B. High speed twist drill

   C. Center punch

   D. Ball-peen hammer

   E. Stock to be drilled

   F. Lubricating oil

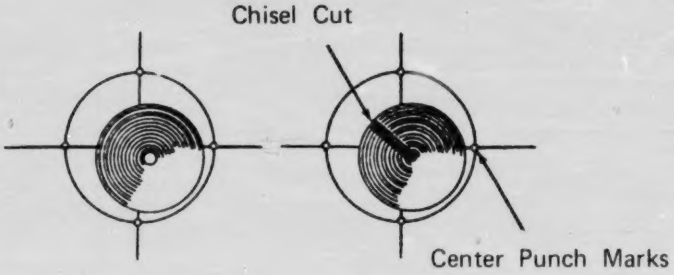
II. Procedure

   A. Make a center punch mark on stock

   B. Enlarge the center punch mark slightly and remove before whole point has entered the material

   C. Make a chisel cut to side which the drill should be drawn (Figure 1)

FIGURE 1



How to Draw the Drill Back to Correct Center

   D. Make another punch mark for new center

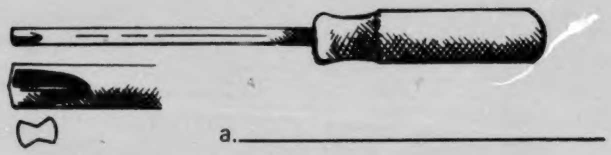
   E. Repeat step B above

HAND TOOLS
UNIT III

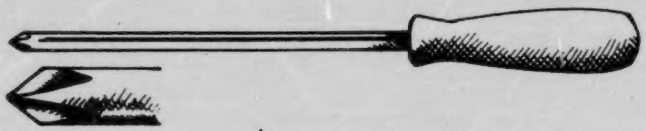
TEST

1. Write the purpose of tools.

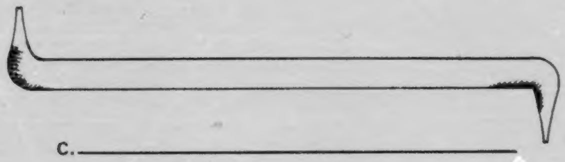
2. Identify the following types of screwdrivers.



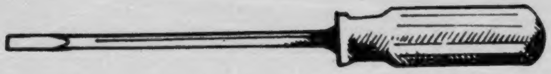
a.________________________________



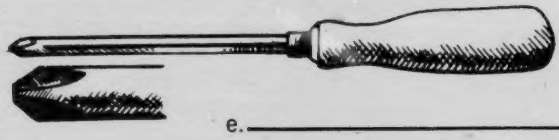
b.________________________________



c.________________________________

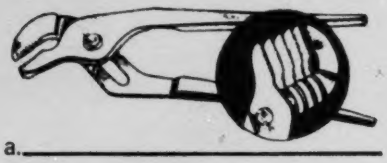


d.________________________________

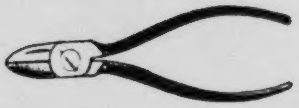


e.________________________________

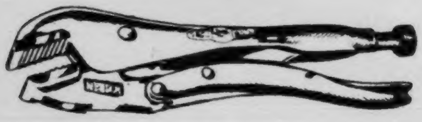
3. Identify the following types of pliers.



a. ____________________



b. ____________________



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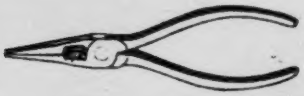
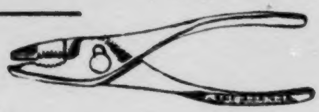
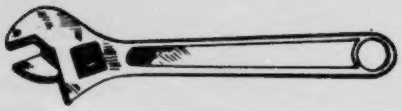


d. ____________________

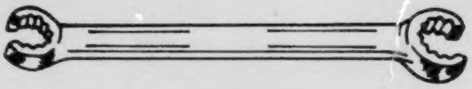


e. ____________________

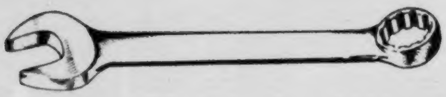
4. Identify the following types of wrenches.



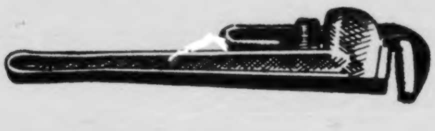
a. ____________________



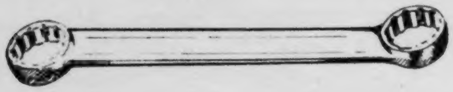
b. ____________________



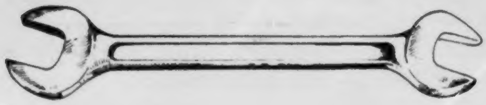
c. ____________________



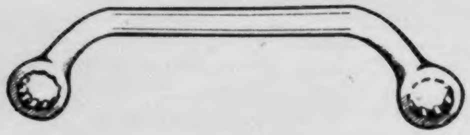
d. ____________________



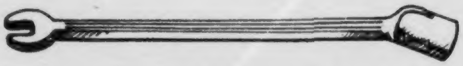
e. ____________________



f. ____________________

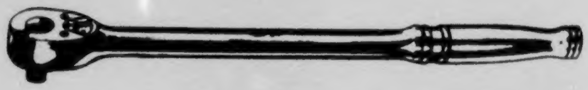


g. ____________________

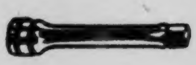


h. ____________________

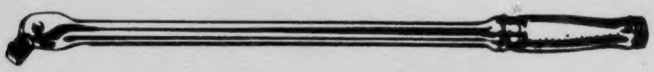
5. Identify the following components of a socket set.



a. ______________________________



b. ______________________________



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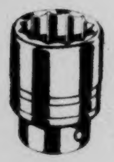
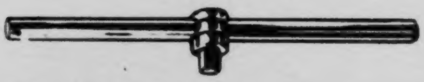
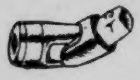


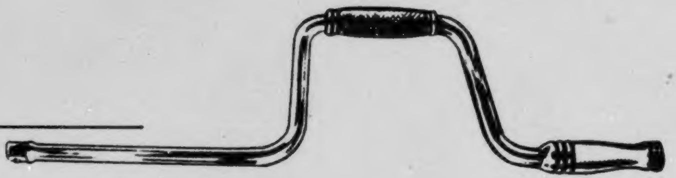
d. ______________________________



e. ______________________________



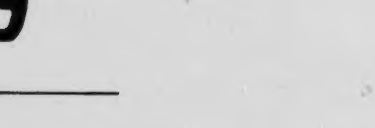
f. ______________________________



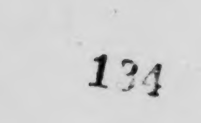
g. ______________________________

6. Identify the following types of sockets.

a. ______________________________

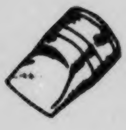


b. ______________________________

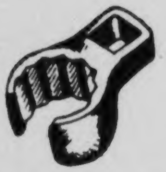


c. ______________________________

7. Identify the following special purpose sockets.



a. ______________________________



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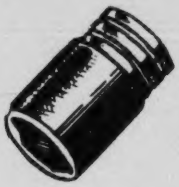

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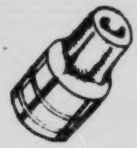
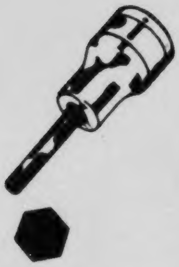
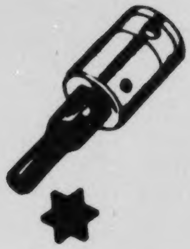


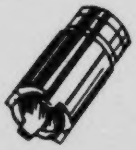
d. ______________________________



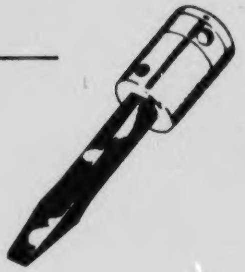
e. ______________________________



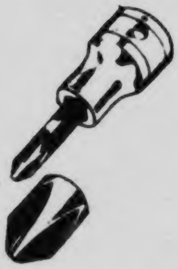
f. ______________________________



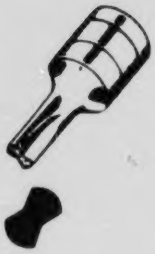
g. ______________________________



h. ______________________________

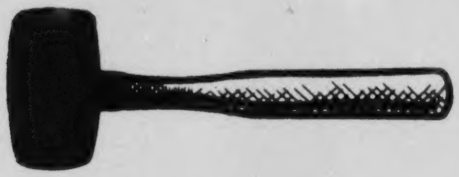


i. ______________________________

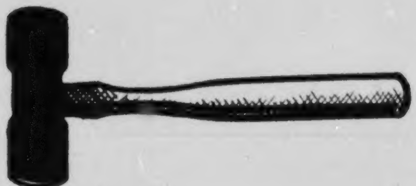


j. ______________________________

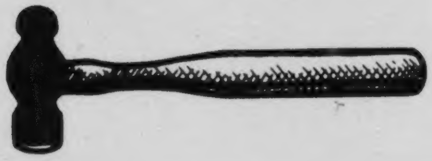
8. Identify the following types of hammers used in the auto shop.



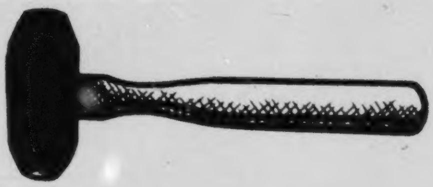
a. ______________________________



b. ______________________________

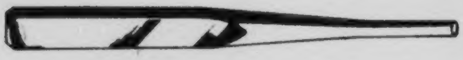


c. ______________________________

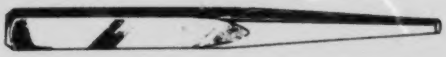


d. ______________________________

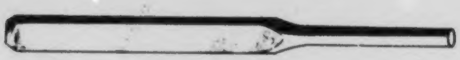
9. Identify the following types of punches.



a. ______________________________

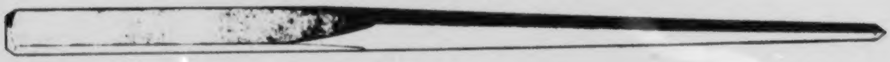


b. ______________________________



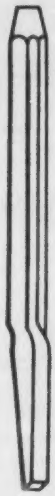
c. ______________________________

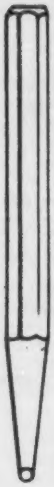
d. ______________________________

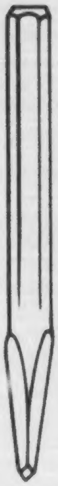


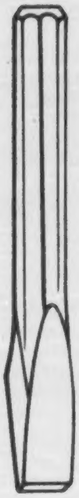
e. ______________________________

10. Identify the following types of chisels.



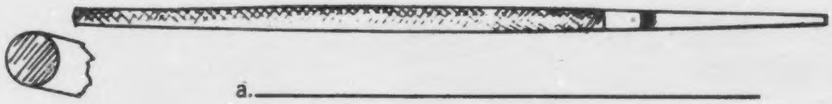




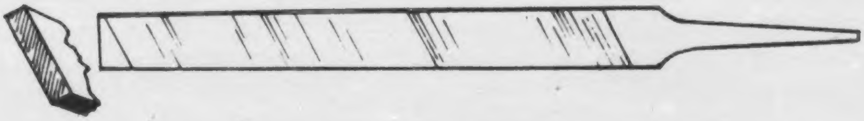


a.______________ b.______________ c.______________ d.______________

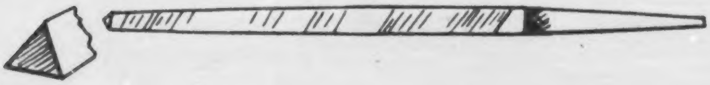
11. Identify the following types of files.



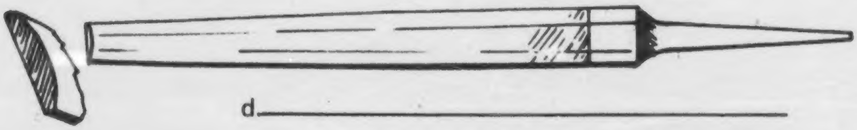
a.______________________________



b.______________________________

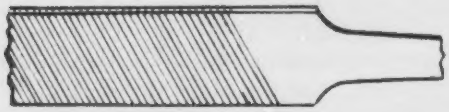


c.______________________________

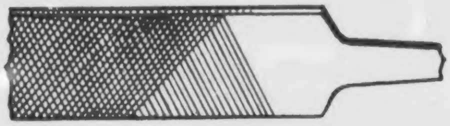


d.______________________________

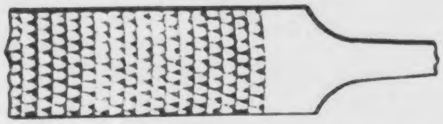
12. Identify the following types of file teeth.



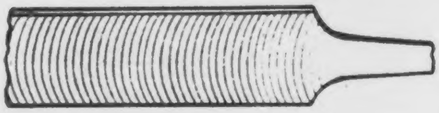
a. ______________________________



b. ______________________________

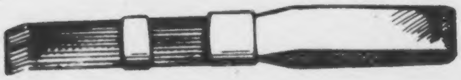


c. ______________________________

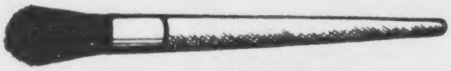


d. ______________________________

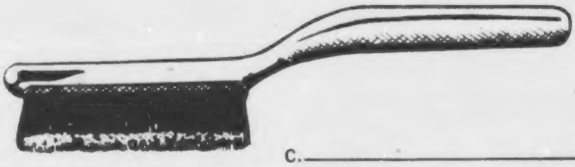
13. Identify the following parts cleaning tools.



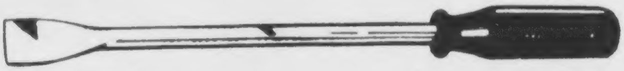
a. ______________________________



b. ______________________________

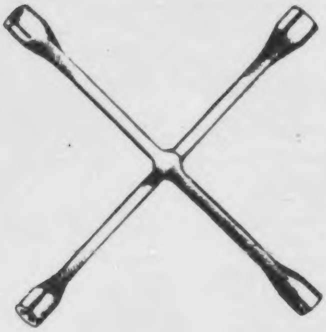


c. ______________________________

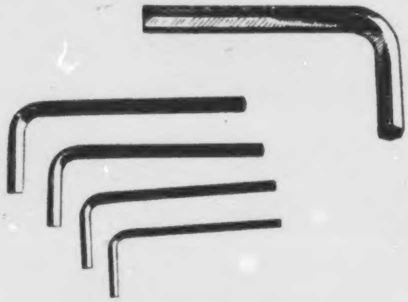


d. ______________________________

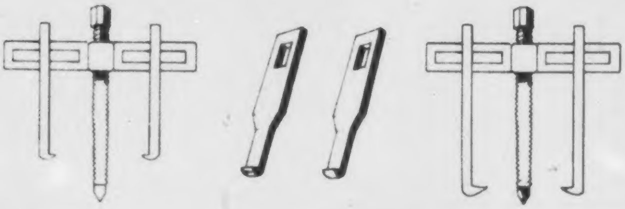
14. Identify the following general shop tools.



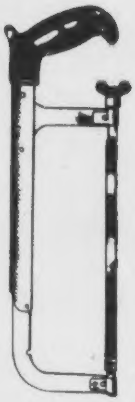
a. ______________________________



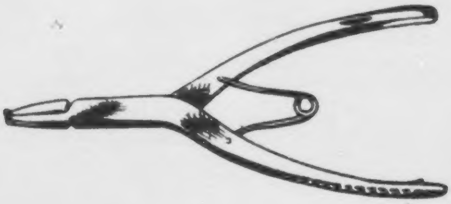
b. ______________________________



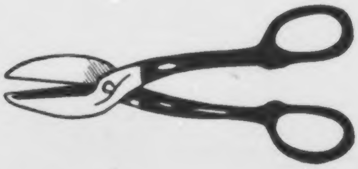
c. ______________________________



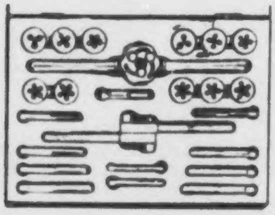
d. ______________________________



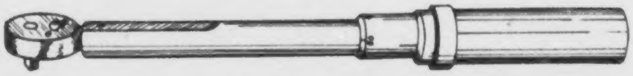
e. ______________________________



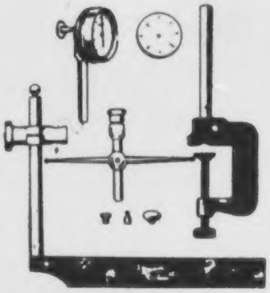
f. ______________________________



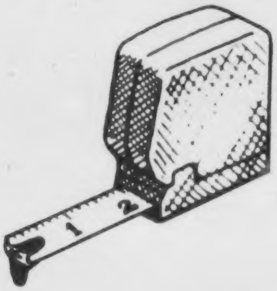
g. ______________________________



h. ______________________________

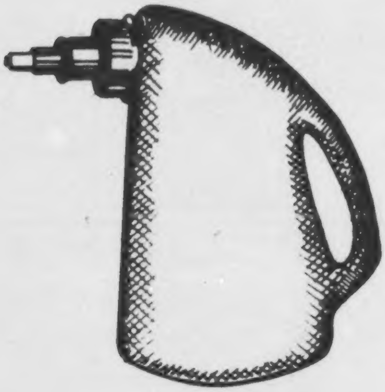


i. ______________________________

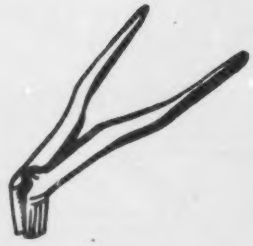


j. ______________________________

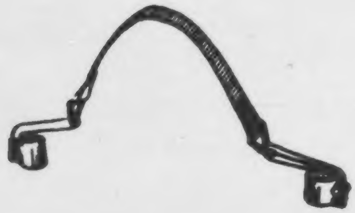
15. Identify the following battery service tools.



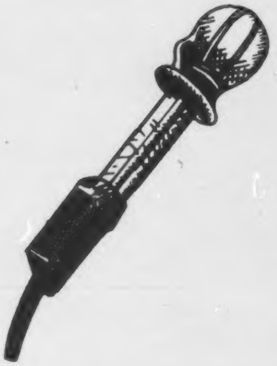
a. ______________________________



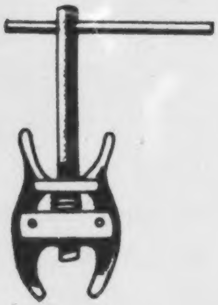
b. ______________________________



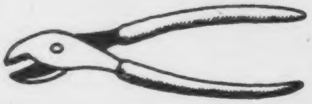
c. ______________________________



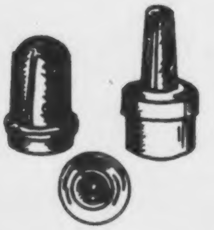
d. ______________________________



e. ______________________________

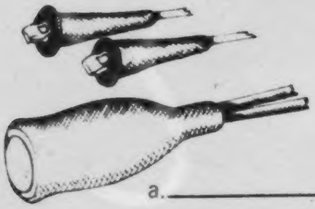


f. ______________________________

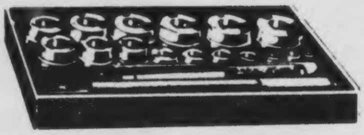


g. ______________________________

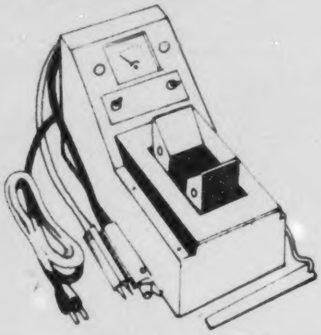
16. Identify the following starter service tools.



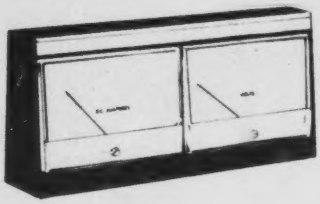
a.________________________



b.________________________

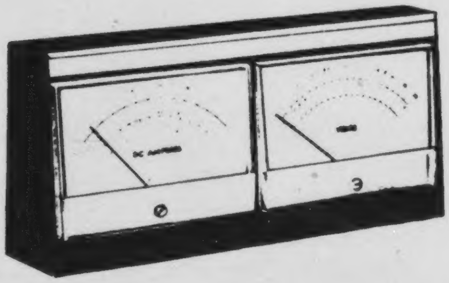


c.________________________

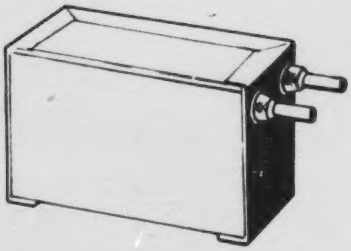


d.________________________

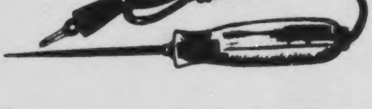
17. Identify the following charging system service tools.



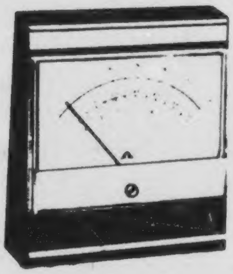
a.________________________



b.________________________

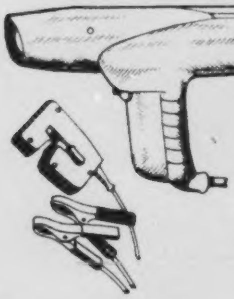


c.________________________

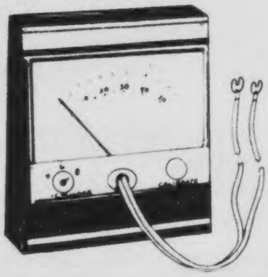


d.________________________

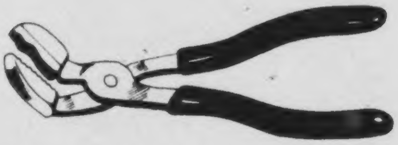
18. Identify the following ignition service tools.



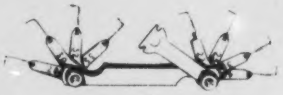
a. ____________________



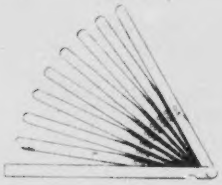
b. ____________________



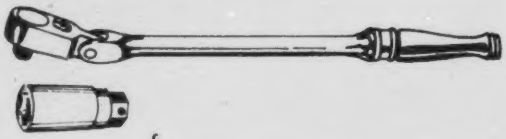
c. ____________________



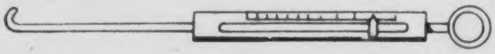
d. ____________________



e. ____________________

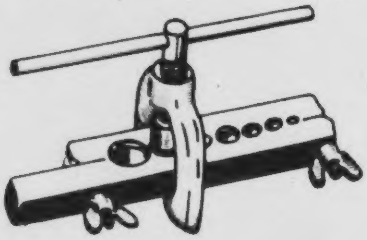


f. ____________________

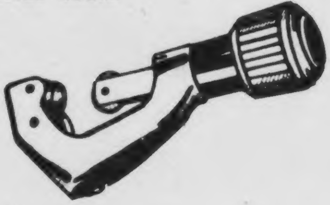


g. ____________________

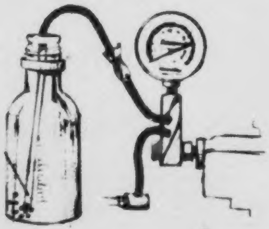
19. Identify the following fuel system service tools.



a. ____________________

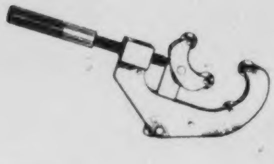


b. ____________________

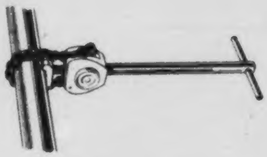


c. ____________________

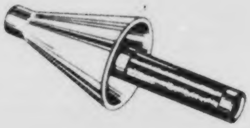
20. Identify the following exhaust service tools.



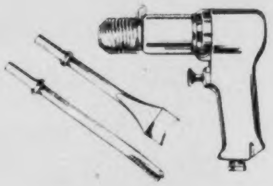
a. ____________________



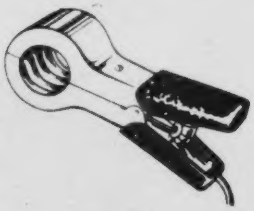
b ____________________



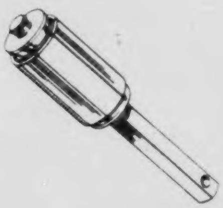
c. ____________________



d. ____________________

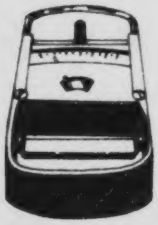


e. ____________________

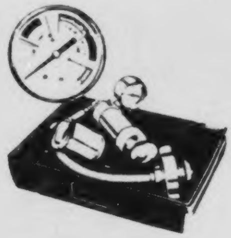


f. ____________________

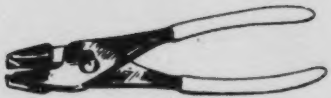
21. Identify the following cooling system service tools.



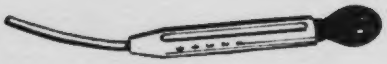
a ____________________



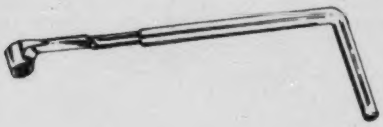
b. ____________________



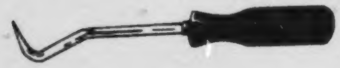
c. ____________________



d. ____________________

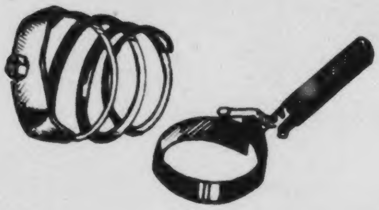


e. ____________________

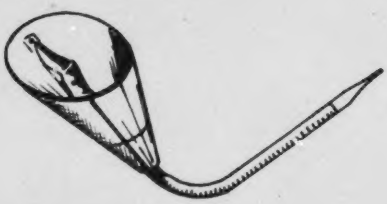


f. ____________________

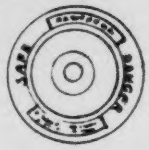
22. Identify the following lubrication service tools.



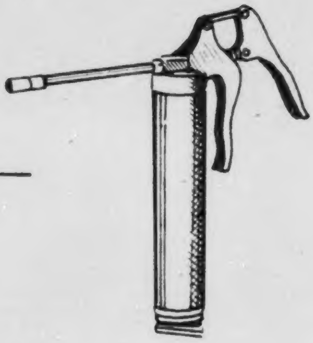
a. ____________________

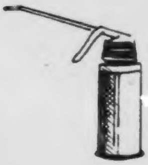


b. ____________________


SAFE
DANGER

c. ____________________





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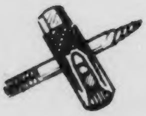

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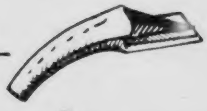
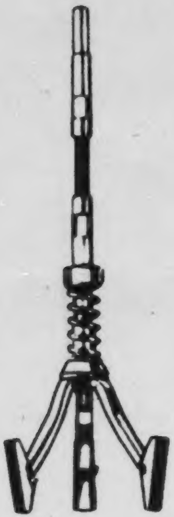


f. ____________________

g. ____________________

23. Identify the following brake service tools.



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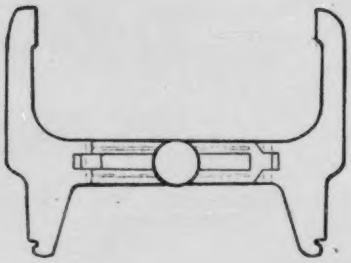

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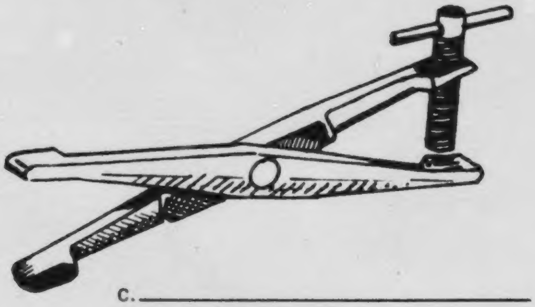

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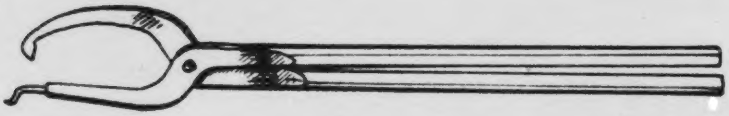

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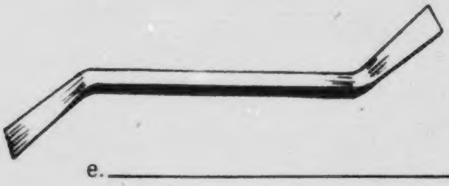

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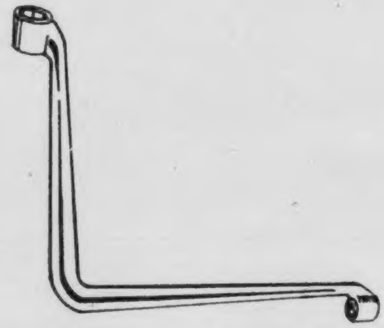

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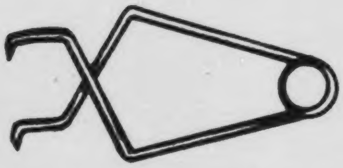
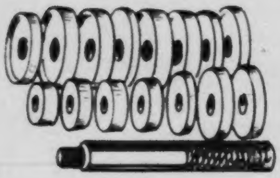


g. ______________________________

24. Identify the following front-end service tools.



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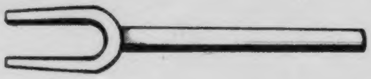

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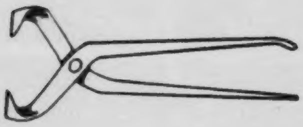

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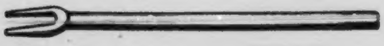

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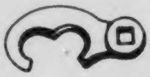
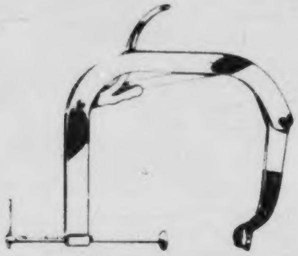


e. ____________________

25. Identify the following engine repair tools.



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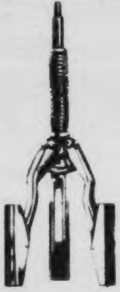

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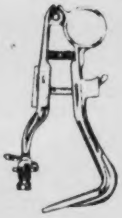

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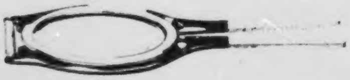

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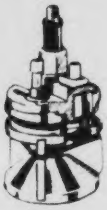

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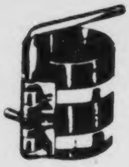

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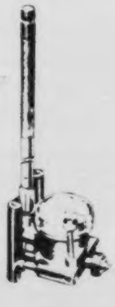

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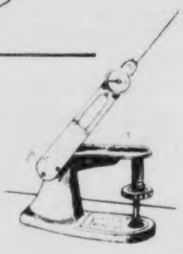
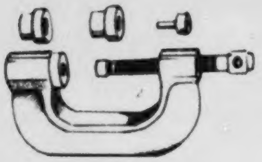


h. ____________________

26. Identify the following drive line tools.



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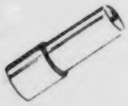

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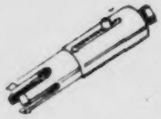

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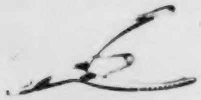

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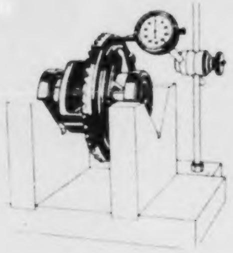

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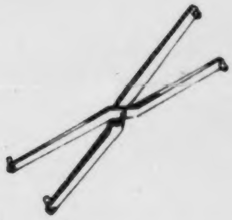

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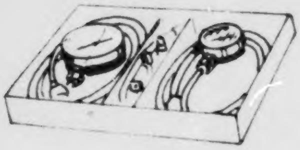

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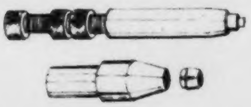

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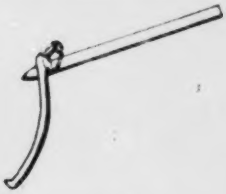


i. ______________________

27. Demonstrate the ability to:

a. Sharpen a twist drill.

b. Drill holes with a drill press.

c. Reshape a cold chisel.

d. Cut flat metal with a cold chisel.

e. Dress a grinding wheel.

f. Fit a screwdriver.

g. Replace a hammer handle.

h. Check a torque wrench for accuracy.

i. Draw file a flat surface.

j. Draw a twist drill hole to correct center.

(NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

HAND TOOLS
UNIT III

ANSWERS TO TEST

1. To allow the mechanic to perform a variety of service procedures quickly and efficiently

2.
    a. Clutch
    b. Reed and prince
    c. Offset
    d. Standard or common
    e. Phillips

3.
    a. Channel lock
    b. Diagonal side cutter
    c. Lock grip
    d. Needle nose
    e. Slip joint

4.
    a. Adjustable end wrench
    b. Tubing wrench
    c. Combination end
    d. Pipe wrench
    e. Box end
    f. Open end
    g. Obstruction box end
    h. Flex head

5.
    a. Ratchet handle
    b. Extension
    c. Break-over handle
    d. Socket

e. Sliding T-handle
f. Universal joint
g. Speed handle

6. a. Universal
b. Deep well
c. Standard

7. a. Drag link
b. Crowfoot
c. Oil sender
d. Shock absorber
e. Allen or hex head
f. Triple square cap
g. Prong nut or dash nut
h. Standard
i. Phillips
j. Clutch

8. a. Rubber
b. Plastic tip
c. Ball-peen
d. Brass

9. a. Pin
b. Starting
c. Drift
d. Center
e. Lining-up

10. a. Cape
    b. Round nose
    c. Diamond point
    d. Cold
11. a. Round
    b. Flat
    c. Triangle
    d. Half round
12. a. Single cut
    b. Double cut
    c. Rasp cut
    d. Curved
13. a. Carbon scraper
    b. Parts cleaning brush
    c. Wire brush
    d. Gasket scraper
14. a. Lug wrench
    b. Allen wrench set
    c. Puller set
    d. Hacksaw
    e. Snap-ring pliers
    f. Metal cutting shears
    g. Tap and die set
    h. Torque wrench
    i. Dial indicator set
    j. Measuring tape

15. a. Battery filler
    b. Cable spreader
    c. Lifting strap
    d. Hydrometer
    e. Cable puller
    f. Terminal pliers
    g. Post and cable cleaner
16. a. Remote control starter switch
    b. Bushing driver set
    c. Growler
    d. Amp-volt tester
17. a. Amp-volt tester
    b. Diode tester
    c. Continuity light
    d. Ohmmeter
18. a. Timing light
    b. Dwell meter
    c. Insulated pliers
    d. Spark plug gauge
    e. Feeler gauge
    f. Spark plug ratchet and socket
    g. Spring gauge
19. a. Tube flaring tool
    b. Tube cutter
    c. Fuel pump tester

20. a. Hand pipe cutter
b. Chain wrench
c. Straightening cone
d. Power chisel
e. Electric pipe joint heater
f. Pipe expanding tool

21. a. Belt tension gauge
b. Radiator pressure tester
c. Hose clamp pliers
d. Antifreeze tester
e. Fan wrench
f. Radiator hose remover tool

22. a. Oil filter removing tools
b. Transmission filler funnel
c. PCV tester
d. Grease gun
e. Oil can
f. Grease fitting tool
g. Oil spout

23. a. Cylinder hone
b. Brake shoe adjusting gauge
c. Disc brake pad spreader
d. Spring pliers
e. Adjusting tool
f. Bleeder wrench
g. Cylinder clamp

24. a. Seal driver set
    b. Ball joint removing tool
    c. Dust cover remover
    d. Tie-rod end removing tool
    e. Toe-in adjusting wrench
25. a. Valve spring compressor
    b. Cylinder deglazing hone
    c. Piston ring groove cleaner
    d. Piston ring expander
    e. Ridge reamer
    f. Piston ring compressor
    g. Cylinder taper gauge
    h. Valve spring pressure tester
26. a. Universal joint press set
    b. Transmission bushing driver
    c. Transmission bushing puller
    d. Snap-ring pliers
    e. Dial indicator
    f. Differential adjusting tool
    g. Automatic transmission pressure gauge set
    h. Clutch aligning set
    i. Flywheel turner
27. Performance skills evaluated to the satisfaction of the instructor

ARC WELDING
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to name kinds of arc welders, select equipment needed, and list safety precautions observed in arc welding. The student should be able to strike an arc, run a bead, and construct a butt weld. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with arc welding to the correct definitions.
2. List safety precautions used in arc welding.
3. Name kinds of arc welders.
4. Select from a list common equipment used in arc welding.
5. List types of electrodes.
6. Select from a list the common sizes of electrodes used in arc welding.
7. Identify the meanings of the numbers in the electrode classification system.
8. Select from a list purposes of electrode coating.
9. List factors to consider in selecting electrodes.
10. Describe the effects of raising and lowering the arc welding current.
11. Name two methods of striking an arc.
12. Select from a list characteristics of proper arc length.
13. Label the parts of a drawing showing the welding process.
14. Identify kinds of welds.
15. Identify types of weld joints.

16. Name the welding positions.

17. List reasons for poor welds.

18. Demonstrate the ability to:
    - a. Start, stop, and restart a bead.
    - b. Construct a pad weld.
    - c. Construct a butt weld.

ARC WELDING
UNIT IV

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined on the job sheets.

   G. Give test.

   (NOTE: There are several good films and filmstrips available from the various welding supply companies. See your local distributor about films and filmstrips that are available.)

II. Student:

   A. Read objective sheet.

   B. Study information sheet and take additional notes as necessary.

   C. Demonstrate the ability to accomplish the procedures outlined on the job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Welding Equipment

      2. TM 2--AWS Classification of Electrodes

3. TM 3--Methods of Striking an Arc
4. TM 4--Welding Process
5. TM 5--Kinds of Welds
6. TM 6--Types of Weld Joints
7. TM 7--Welding Positions

D. Job sheets

1. Job Sheet #1--Start, Stop, and Restart a Bead
2. Job Sheet #2--Construct a Pad Weld
3. Job Sheet #3--Construct a Butt Weld

E. Test

F. Answers to test

II. References:

A. Jones, M. M. *Shopwork on the Farm.* 2d ed. New York: McGraw-Hill Book Co., Inc., 1955.

B. Phipps, Lloyd J.; McColly, H. F.; Scranton, L. L.; and Cook, G. C. *Farm Mechanics Text and Handbook.* Danville, Illinois: The Interstate Printers and Publishers, Inc., 1964.

C. Kugler, Harold L. *Arc Welding Lessons for School and Farm Shop.* 2d ed. Cleveland, Ohio: James F. Lincoln Arc Welding Foundation, 1957.

D. Hallenberg, A. H. *How to Teach Arc Welding in Farm Mechanics.* Cleveland, Ohio: James F. Lincoln Arc Welding Foundation.

E. *Hobart Welding School Workbook.* Troy, Ohio: Hobart Brothers' Technical Center.

F. *New Lessons in Arc Welding.* Cleveland, Ohio: The Lincoln Electric Co./James F. Lincoln Arc Welding Foundation.

G. Pierre, E. R. *Welding Processes and Power Sources.* Study guide and workbook. Appleton, Wisconsin: Power Publications Co., 1968-69.

H. Jefferson, T. B. *The Welding Encyclopedia.* Morton Grove, Illinois: Monticello Books, 1968.

I. Cowan, Earl; Braker, Clifton; Penner, Wayman; and Patton, Bob. *Welding.* Stillwater: Oklahoma State Department of Vocational and Technical Education, 1974.

ARC WELDING
UNIT IV

INFORMATION SHEET

I. Terms and definitions

A. Base metal--Metal to be cut or welded (Transparency 4)

B. Arc--Flow of current across a narrow gap, usually from the tip of the electrode to the base metal (Transparency 4)

C. Fusion process--Process of heating metal to a molten state and allowing it to cool

(NOTE: The heat is produced by the electric arc in arc welding.)

D. Arc welding--Joining together of two or more pieces of metal by the fusion process

(NOTE: This is sometimes referred to as *shielded metal arc welding* or *SMAW*.)

E. Crater--Depression at the termination of a weld (Transparency 4)

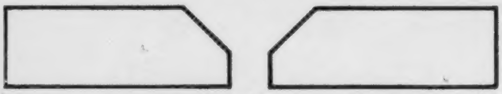
F. Pass--Single longitudinal progression of a welding operation along a joint or weld deposit

G. Electrode--Metal rod which conducts a current from the electrode holder to the base metal (Transparency 4)

(NOTE: The metal rod melts and deposits the metal in a bead.)

H. Bead weld--Weld made by one pass of an electrode (Transparency 5)

I. Bevel--Angular cut made on the vertical edge to allow better weld penetration



J. Butt joint--Weld between two metal joints on the same plane (Transparency 6)

K. Tack weld--Weld made to hold parts in proper alignment until the final welds are made

(NOTE: This type of welding is for assembly purposes only.)

L. Puddle--That portion of a weld that is molten at the place the heat is supplied (Transparency 4)

M. AWS--American Welding Society

INFORMATION SHEET

II. Safety precautions in arc welding

A. Do not look at the arc without eye protection

B. Wear a head or face shield that is in good condition

C. Wear suitable clothing to protect all parts of the body

Examples: Long-sleeved shirt, leather gloves, turned-down cuffs, high top shoes or boots, buttoned-down collar

D. Do not strike an arc or weld until you are sure those in the vicinity have protective equipment or will look the other direction

(NOTE: Shout "Cover" before striking the arc.)

E. Do not weld around combustible or flammable materials

F. Do not pick up hot metal

G. Do not weld in confined places without proper ventilation

H. Open main switch or disconnect plug when checking a welder

I. Do not leave electrode holder on welding table or in direct contact with grounded metal

J. Do not use worn or frayed cables

K. Stand on dry footing when welding

L. Keep areas around welder clean

M. Keep tools and metals in proper location

(NOTE: Others may be added by instructor.)

III. Kinds of arc welders

A. AC or alternating current

(NOTE: Welder current alternates direction 120 times per second.)

B. DC or direct current

(NOTE: Welder current flows in the same direction.)

INFORMATION SHEET

C. Motor generator

(NOTE: This generator produces only DC current.)

D. Engine generator

(NOTE: This alternating type generator will produce either AC or DC current.)

E. AC/DC transformer-rectifier

(NOTE: This welder, which is supplied by an AC power source, can be switched to produce either AC or DC welding current.)

IV. Common welding equipment (Transparency 1)

A. Welding machine

B. Electrode holder with lead

C. Ground clamp with lead

D. Shield or helmet

E. Gloves

F. Chipping hammer

G. Safety goggles or glasses

H. Wire brush

I. Electrode

V. Types of electrodes

A. Mild steel

B. High carbon steel

C. Hard surfacing

D. Low hydrogen

E. Alloy

(NOTE: Alloy electrodes are used for welding special metals such as cast iron and aluminum.)

INFORMATION SHEET

VI. Common sizes of electrodes

(NOTE: Electrodes range in size from 1/16" to 5/16".)

A. 3/32"

B. 1/8"

C. 5/32"

D. 3/16"

VII. Meanings of numbers in the electrode classification system (Transparency 2)

A. E--Stands for electric arc welding

B. First two digits--Indicate tensile strength deposited in thousand pounds per square inch

C. Third digit--Indicates welding position

1. "1" indicates all positions
2. "2" indicates flat and horizontal only
3. "3" indicates flat only

D. Fourth or last digit--Represents special characteristics and usability of the electrode

Example:

Last Digit	Last-Digit Characteristics			
	Power Supply	Arc Action	Type of Flux	Penetration Characteristics
0	10, DC+; 20, AC; or DC	Digging	10, organic; 20, mineral	10, deep 20, medium
1	AC or DC+	Digging	Organic	Deep
2	AC or DC	Medium	Ductile	Medium
3	AC or DC	Soft	Ductile	Light
4	AC or DC	Soft	Ductile	Light
5	DC+	Medium	Low hydrogen	Medium
6	AC or DC+	Medium	Low hydrogen	Medium
7	AC or DC	Soft	Mineral	Medium
8	AC or DC+	Medium	Low hydrogen	Medium

(Reprinted by permission from T. B. Jefferson, The Welding Encyclopedia, p. E-4, Monticello Books, Morton Grove, Illinois, 1968.)

INFORMATION SHEET

VIII. Purposes of electrode coating

   A. Stabilize the arc

   B. Shield molten puddle from air

   C. Float impurities out of puddle

   D. Form slag and slow cooling

   E. Increase speed

   F. Improve quality of weld

IX. Factors to consider in selecting electrodes

   A. Base metal strength properties

   B. Base metal composition

   C. Welding position

   D. Welding current

   E. Joint design and fit-up

   F. Thickness and shape of base metal

   G. Production efficiency and job conditions

X. Effects of raising and lowering arc welding current

   A. Raising the current produces more heat

   B. Lowering the current produces less heat

XI. Methods of striking an arc (Transparency 3)

   A. Scratching

   (NOTE: This method is similar to striking a match.)

   B. Tapping

XII. Characteristics of proper arc length

   A. End of electrode is the same distance from the base metal as diameter of electrode

   Example: For a 1/8" electrode the arc length should be 1/8"

INFORMATION SHEET

- B. Correct arc length makes a steady hum of the welder and a "frying" sound at the arc

XIII. Parts of the welding process (Transparency 4)

- A. Electrode
- B. Wire core
- C. Coating (flux)
- D. Arc
- E. Gaseous shield
- F. Weld
- G. Slag
- H. Heat lines
- I. Base metal
- J. Penetration
- K. Crater
- L. 15° - 30° angle of electrode
- M. Direction of travel

XIV. Kinds of welds (Transparency 5)

- A. Fillet
- B. Groove
- C. Bead

XV. Types of weld joints (Transparency 6)

- A. Edge
- B. Butt
- C. Corner
- D. T
- E. Lap

INFORMATION SHEET

XVI. Welding positions (Transparency 7)

- A. Flat
- B. Horizontal
- C. Vertical

  (NOTE: The bead may be started either from the top or the bottom depending on the characteristics of the metal.)

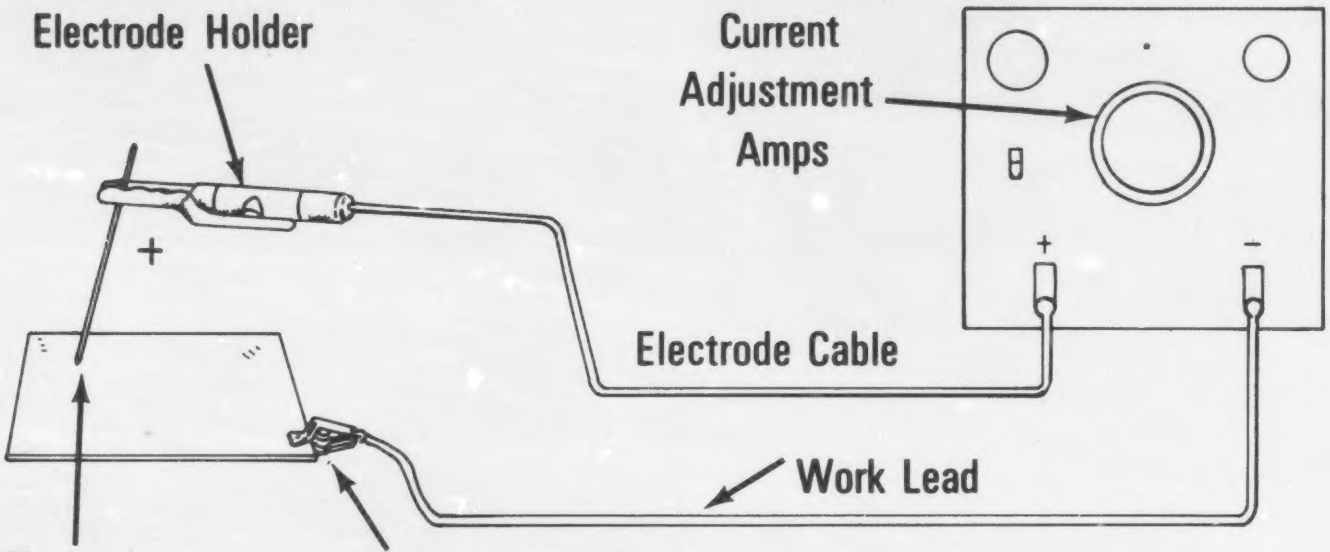
- D. Overhead

XVII. Reasons for poor welds

- A. Machine adjustment too hot or too cool
- B. Electrode size too large or too small
- C. Improper movement of electrode
- D. Improper angle of electrode
- E. Improper base metal preparation
- F. Arc length too long or too short

(NOTE: Others may be added by instructor.)

Welding Equipment



Welding Machine

Electrode Holder

Current
Adjustment
Amps

+

+

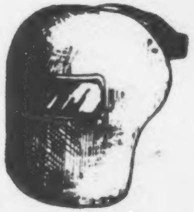
−

Electrode Cable

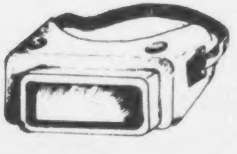
Work Lead

Electrode

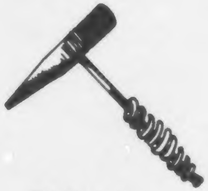
Ground Clamp



Shield or Helmet

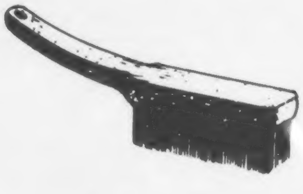


Safety Goggles



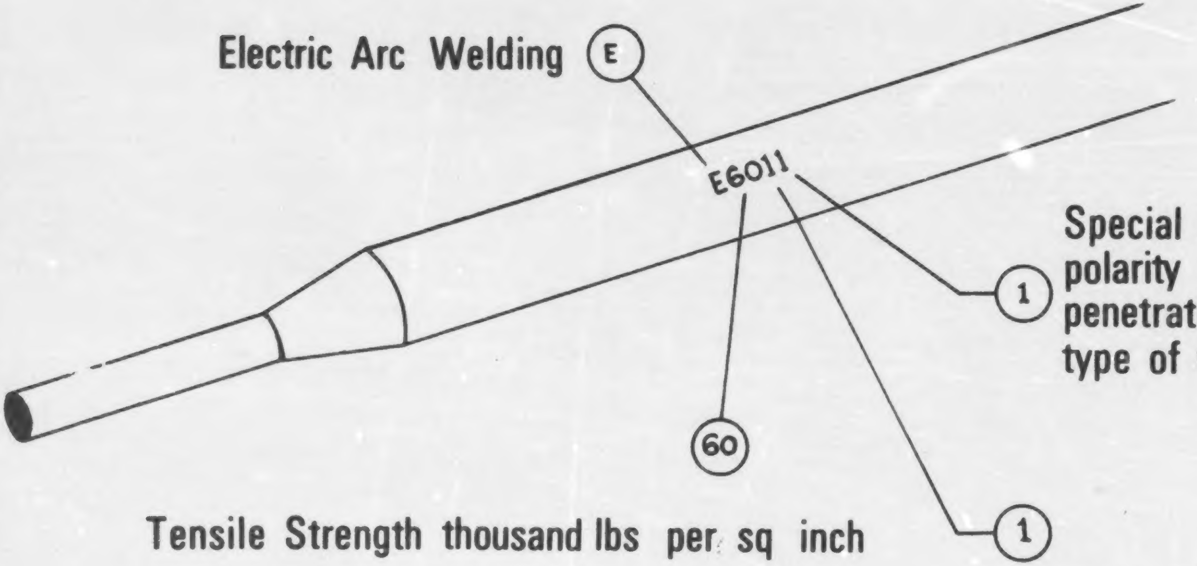
Chipping
Hammer

Gloves



Wire Brush

AWS Classification of Electrodes



Electric Arc Welding (E)

Special char.
polarity
penetration
type of welder

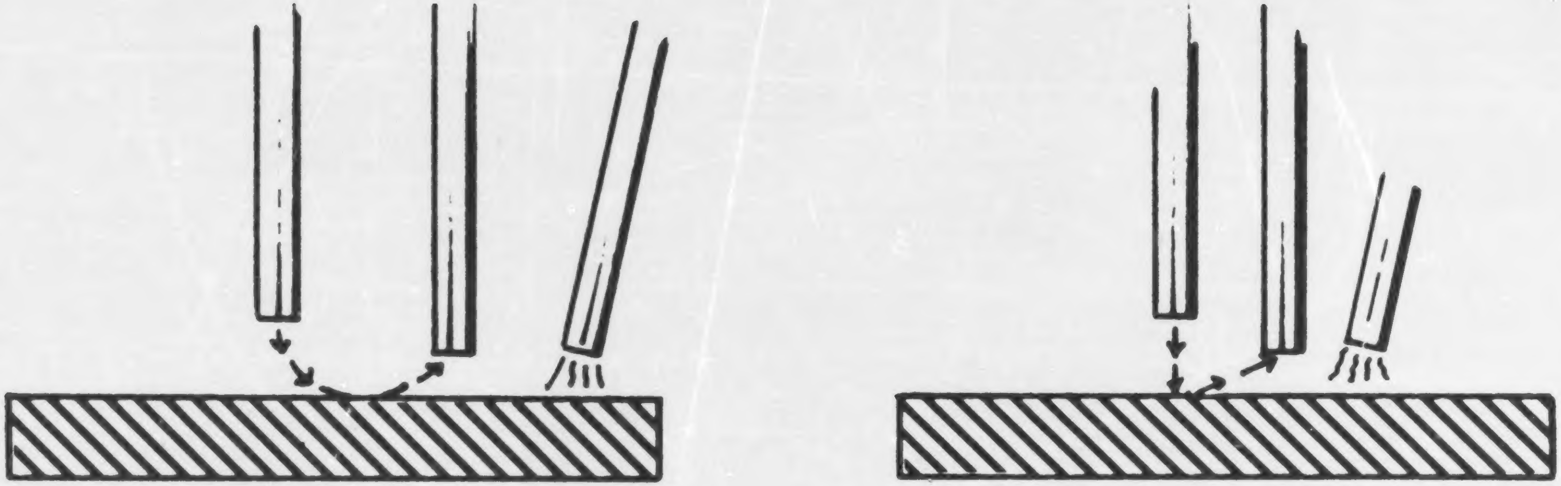
(60)

Tensile Strength thousand lbs per sq inch

Welding Position
1. all positions
2. flat and horizontal
3. flat

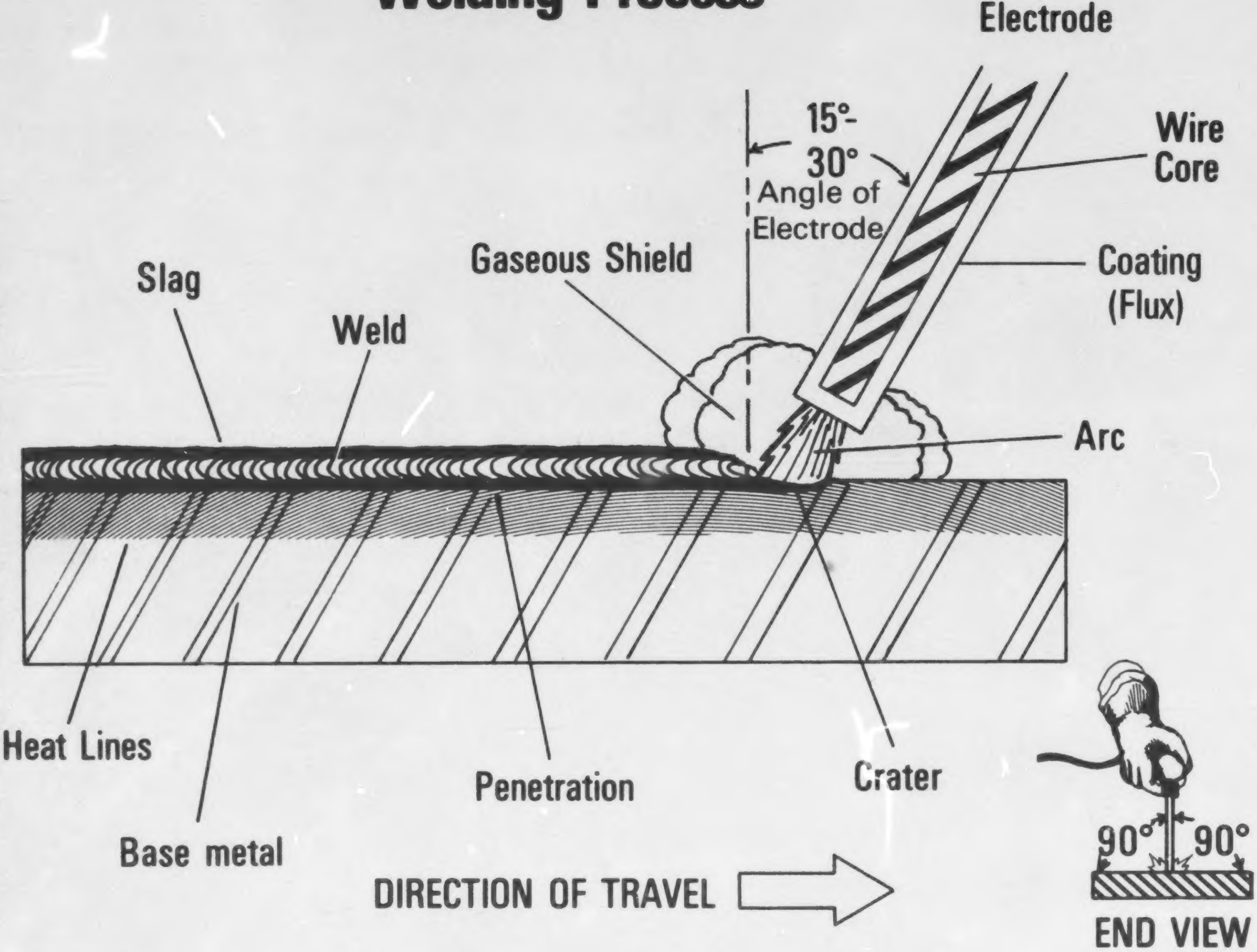
E6011 MILD STEEL ELECTRODE

Methods of Striking an Arc

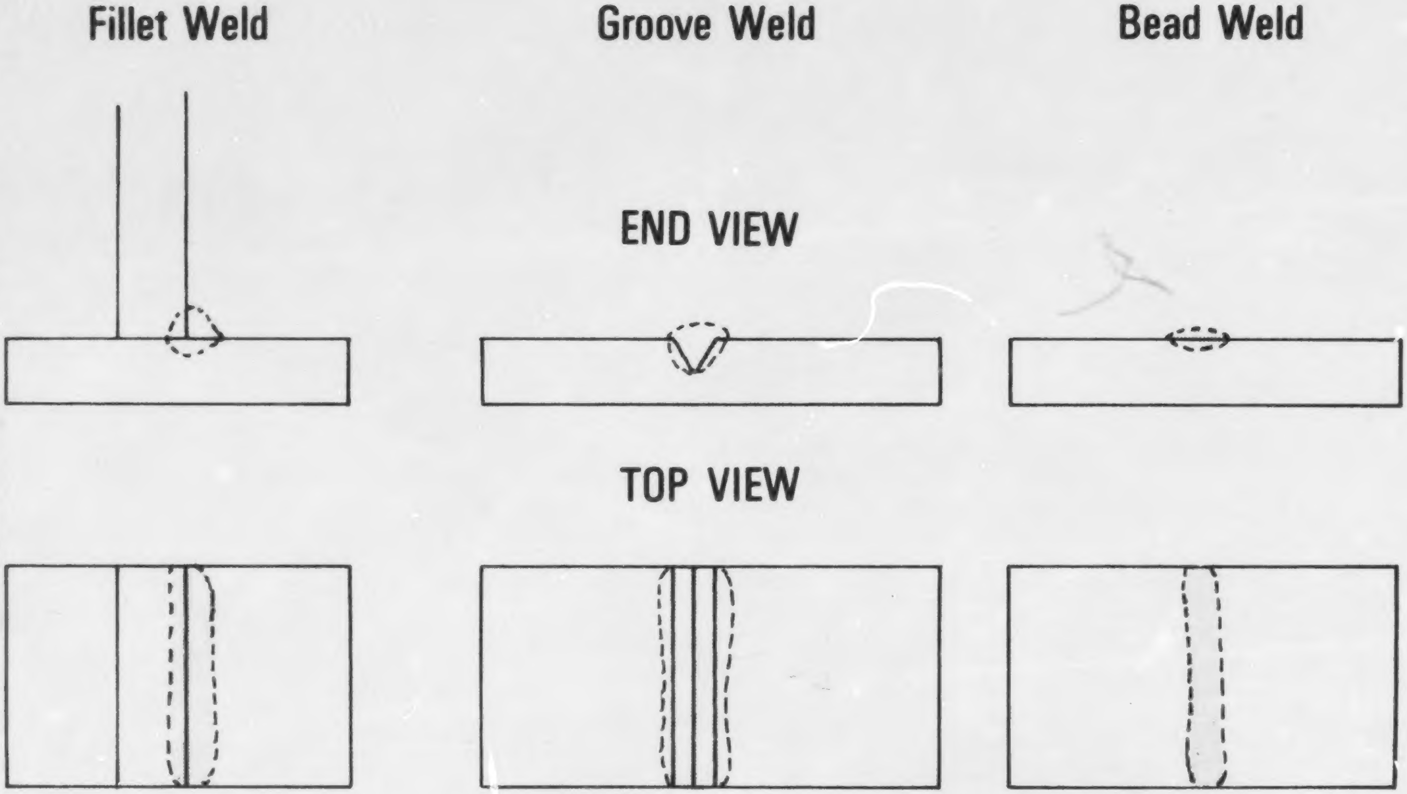


Scratching Tapping

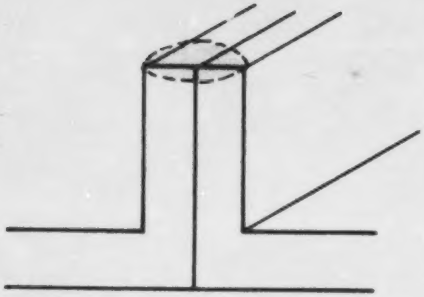
Welding Process


Electrode
15°-
30°
Angle of
Electrode
Wire
Core
Coating
(Flux)
Gaseous Shield
Slag
Weld
Arc
Heat Lines
Penetration
Crater
Base metal
DIRECTION OF TRAVEL
90°
90°
END VIEW

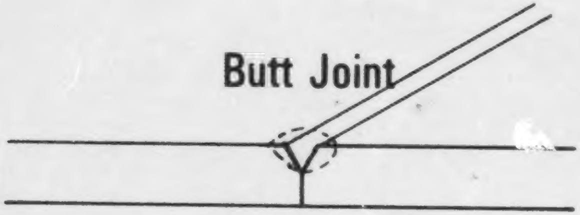
Kinds of Welds


Fillet Weld
Groove Weld
Bead Weld
END VIEW
TOP VIEW

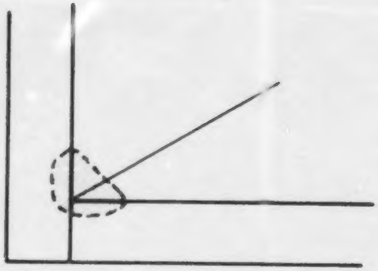
Types of Weld Joints



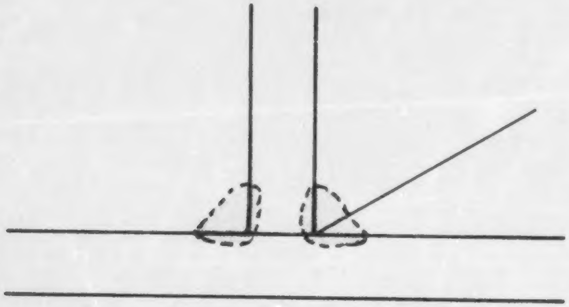
Edge Joint



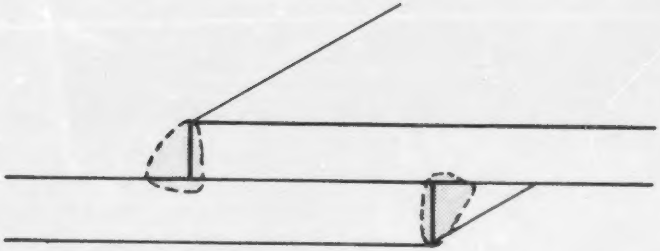
Butt Joint



Corner Joint

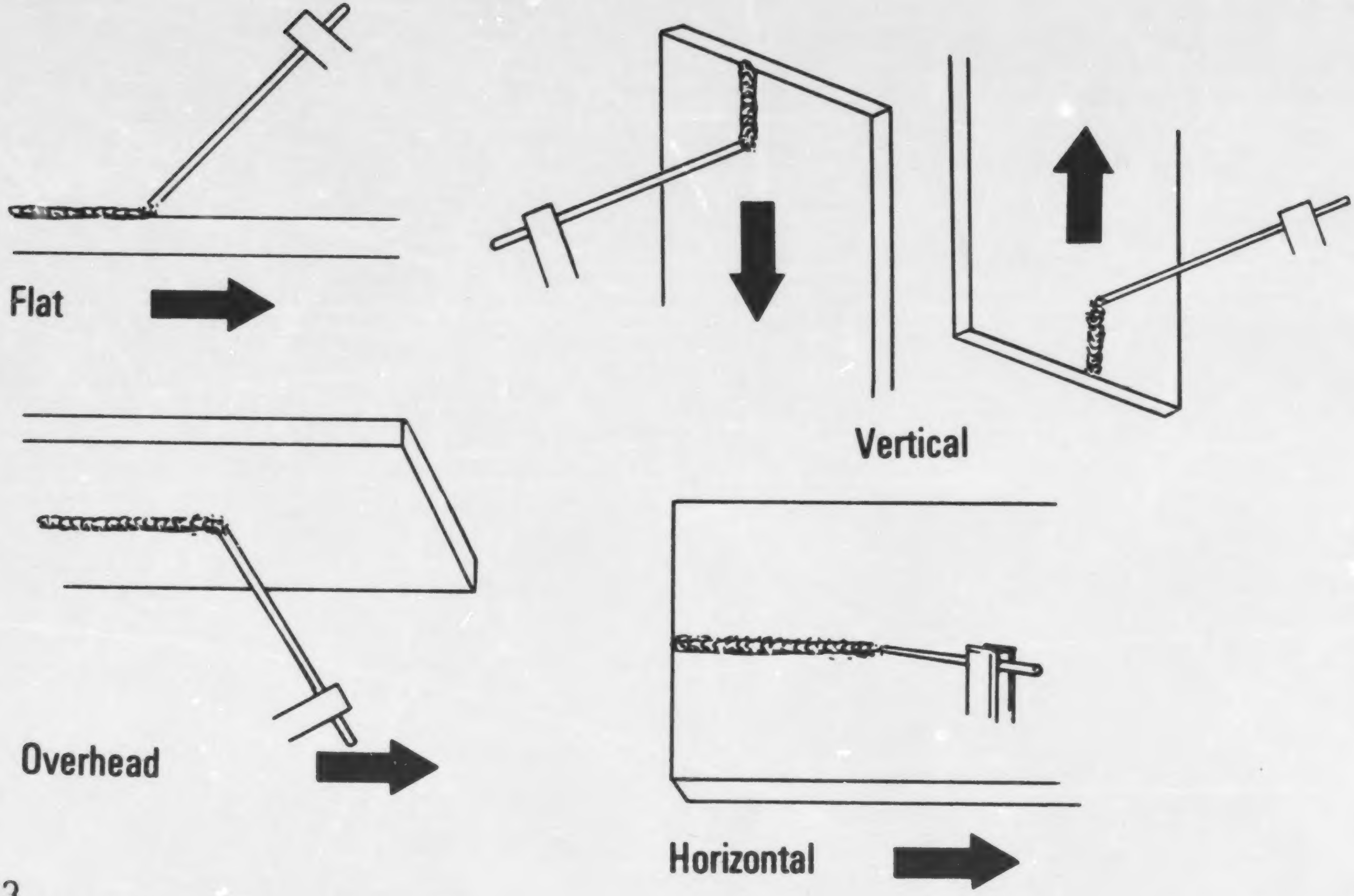


T Joint



Lap Joint

Welding Positions


Flat
Vertical
Overhead
Horizontal

ARC WELDING
UNIT IV

JOB SHEET #1--START, STOP, AND RESTART A BEAD

I. Tools and materials

   A. Piece of metal 1/4" to 3/8" thick, 4" x 4"

   B. Welder

   C. Electrode holder with lead

   D. Ground clamp with lead

   E. Helmet

   F. Gloves

   G. Electrodes

   H. Safety goggles

   I. Chipping hammer

   J. Wire brush

II. Procedure

   A. Prepare metal for welding

   B. Strike arc 1" from edge where bead is to begin (Figures 1 and 2)

FIGURE 1

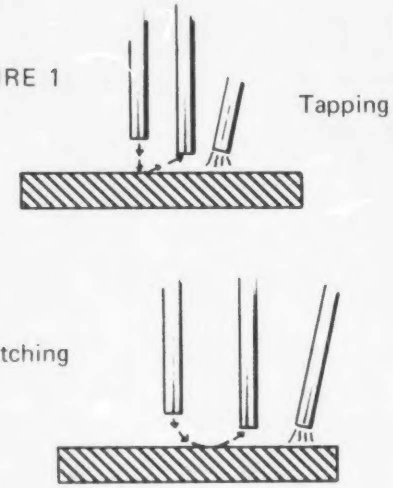
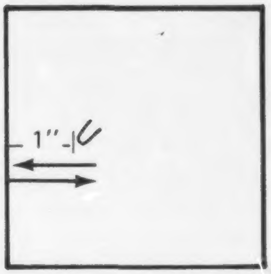


FIGURE 2



7

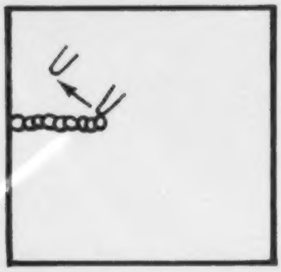
JOB SHEET #1

C. Move to edge when arc burns brightly, maintaining the correct arc length; begin forming the puddle

D. Move across metal two inches

E. Move electrode back through the puddle and lift up to stop bead (Figure 3)

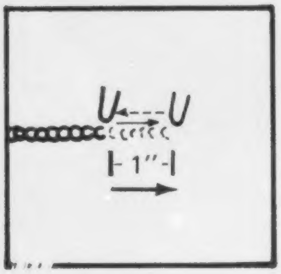
FIGURE 3



(NOTE: This will prevent cracks from forming in the puddle.)

F. Strike arc about 1" in front of crater to restart (Figure 4)

FIGURE 4



G. Move back through the crater when arc burns brightly and then resume the bead

(NOTE: This is necessary in order for beads to blend with one another without a change in continuity.)

ARC WELDING
UNIT IV

JOB SHEET #2--CONSTRUCT A PAD WELD

I. Tools and materials

   A. Piece of metal 1/4" to 3/8" thick, 4" x 4"

   B. Welder

   C. Electrode holder with lead

   D. Ground clamp with lead

   E. Helmet

   F. Gloves

   G. Electrodes

   H. Safety goggles

   I. Chipping hammer

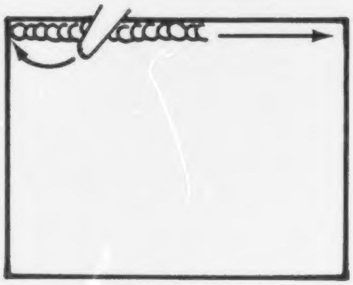
   J. Wire brush

II. Procedure

   A. Prepare metal for welding

   B. Strike arc and move to point to begin pad (Figure 1)

FIGURE 1



   C. Lay a straight bead across the plate using a weaving motion

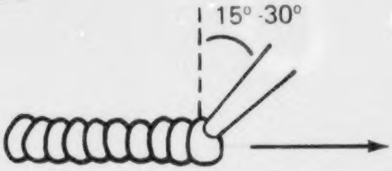
   (NOTE: When using an E6011 electrode, it is necessary to use some type of rod manipulation in running a bead.)

JOB SHEET #2

D. Hold electrode at a 15° to 30° angle in direction of travel and lower electrode as rod burns away to maintain correct arc length (Figure 2)

(NOTE: There should be 90° on each side of the electrode.)

FIGURE 2

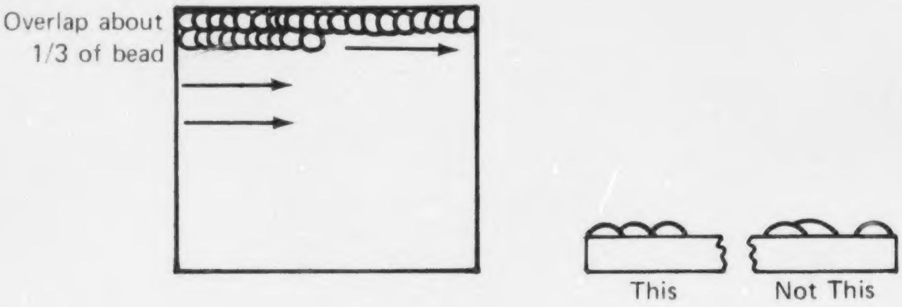


E. Move electrode steadily from right to left across pad

F. Clean the slag from each bead before starting the next one

G. Run beads until pad is full, overlapping each bead (Figure 3)

FIGURE 3



H. Let each bead cool until slag is black before chipping

I. Run additional layers until desired thickness is obtained

ARC WELDING
UNIT IV

JOB SHEET #3--CONSTRUCT A BUTT WELD

I. Tools and materials

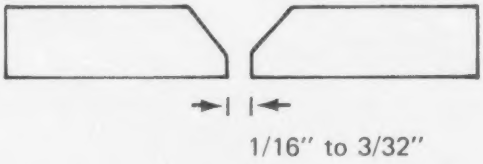
- A. Pieces of metal 1/4" to 3/8" thick, 3" x 6" (2)
- B. Welder
- C. Electrode holder with leads
- D. Ground clamp with leads
- E. Helmet
- F. Gloves
- G. Electrodes
- H. Safety goggles
- I. Chipping hammer
- J. Wire brush

II. Procedure

A. Prepare metal to be welded (Figure 1)

(NOTE: If metal thickness is over 1/8", the edges should be beveled.)

FIGURE 1



Bevel edges

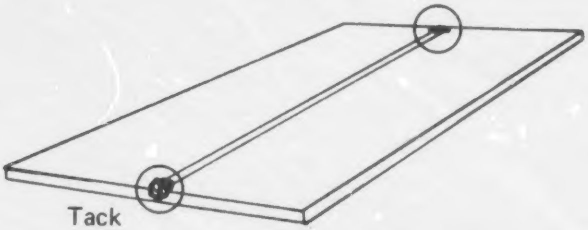
B. Place two pieces of metal parallel to each other

(NOTE: Leave a space from 1/16" to 3/32" between them. See Figure 1.)

JOB SHEET #3

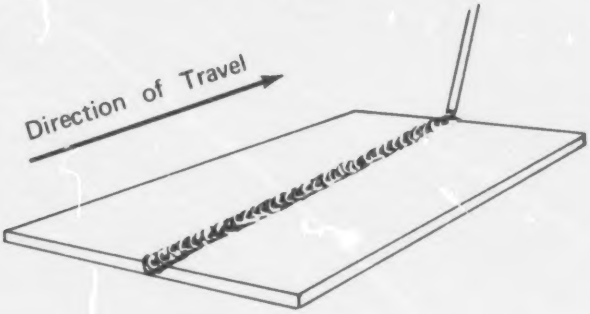
C. Tack weld pieces together at both ends (Figure 2)

FIGURE 2



D. Complete weld using a single pass (Figure 3)

FIGURE 3


Direction of Travel

E. Chip slag and brush weld

ARC WELDING
UNIT IV

TEST

1. Match the terms on the right to the correct definitions.

______a. Metal to be cut or welded

______b. Weld made by one pass of an electrode

______c. Metal rod which conducts a current from the electrode holder to the base metal

______d. Joining together of two or more pieces of metal by the fusion process

______e. Depression at the termination of a weld

______f. Angular cut made on the vertical edge to allow better weld penetration

______g. That portion of a weld that is molten at the place the heat is supplied

______h. Process of heating metal to a molten state and allowing it to cool

______i. Single longitudinal progression of a welding operation along a joint or weld deposit

______j. Weld between two metal joints on the same plane

______k. American Welding Society

______l. Flow of current across a narrow gap, usually from the tip of the electrode to the base metal

______m. Weld made to hold parts in proper alignment until the final welds are made

1. Arc welding
2. Fusion process
3. Arc
4. Base metal
5. Crater
6. Pass
7. Bead weld
8. Bevel
9. Butt joint
10. Tack weld
11. Electrode
12. Puddle
13. AWS

2. List five safety precautions used in arc welding.

   a.

   b.

   c.

   d.

   e.

3. Name two kinds of arc welders.

   a.

   b.

4. Select from the list below common equipment used in arc welding by placing an "X" in the blanks.

   ______a. Welding machine

   ______b. Electrode

   ______c. Gloves

   ______d. Wire brush

   ______e. Cart

   ______f. Shield or helmet

   ______g. Chipping hammer

   ______h. Ball-peen hammer

   ______i. Safety goggles or glasses

   ______j. Hacksaw

   ______k. Screwdriver

5. List three types of electrodes.

   a.

   b.

   c.

6. Select from the list below the common sizes of electrodes used in arc welding by placing an "X" in the blanks.

_____a. 1/16"

_____b. 1/8"

_____c. 3/32"

_____d. 5/16"

_____e. 5/32"

_____f. 3/16"

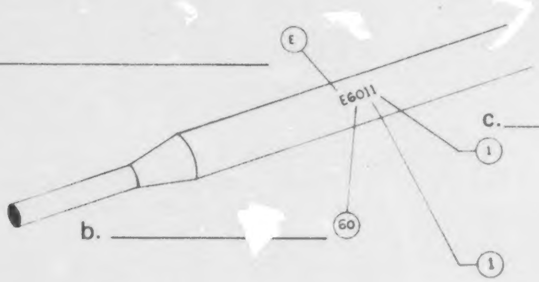
_____g. 3/8"

_____h. 3/64"

_____i. 3/4"

_____j. 1/2"

7. Identify the meanings of the numbers in the electrode classification system.



a. ______________________

b. ______________________

c. ______________________

d. ______________________

8. Select from the list below purposes of electrode coating by placing an "X" in the blanks.

_____a. Increase speed

_____b. Stabilize the arc

_____c. Protect the welder from shock

_____d. Shield molten puddle from air

_____e. Keep electrode from shorting out

_____f. Form slag and slow cooling

_____g. Tack metal to be welded

_____h. Float impurities out of puddle

_____i. Improve quality of weld

9. List four factors to consider in selecting electrodes.

a.

b.

c.

d.

10. Describe the effects of raising and lowering the arc welding current.

11. Name two methods of striking an arc.

a.

b.

12. Select from the list below characteristics of proper arc length by placing an "X" in the blanks.

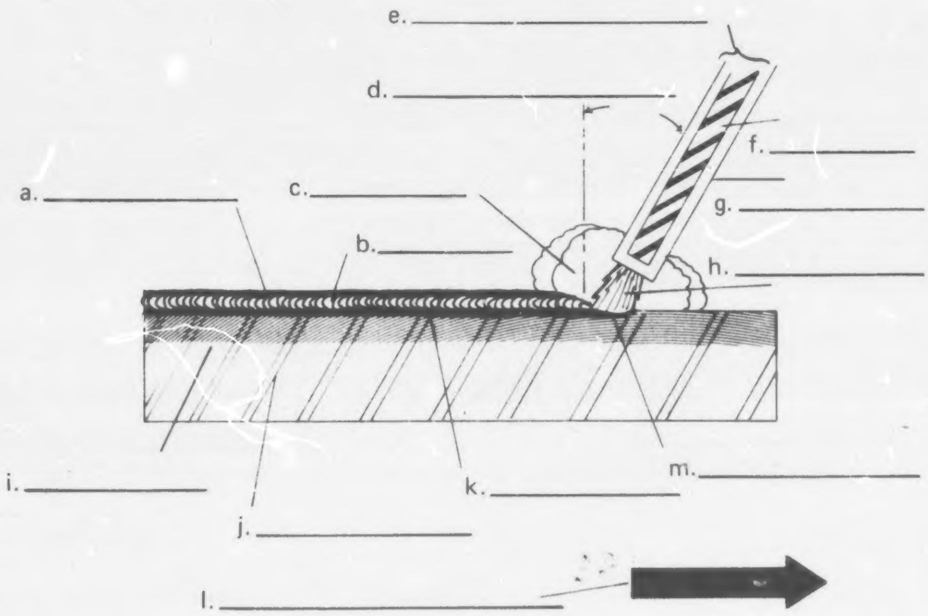
______a. Arc length is 1/2" long

______b. Arc length is the same as the length of the electrode

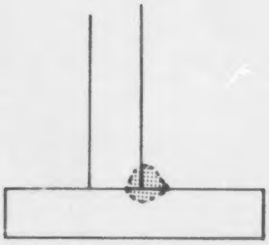
______c. End of electrode is the same distance from the base metal as diameter of electrode

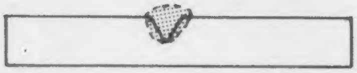
______d. Correct arc length makes a steady hum of the welder and a "frying" sound at the arc

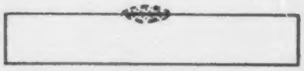
13. Label the parts of the welding process in the drawing below by writing the correct names in the blanks.



14. Identify the following welds.

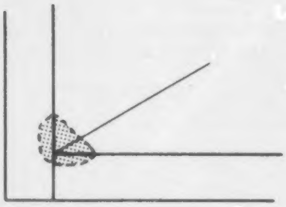


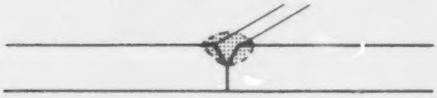




a. ____________________ b. ____________________ c. ____________________

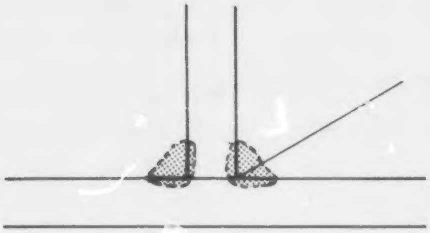
15. Identify the following weld joints.

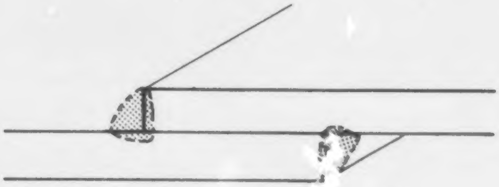




a. ____________________

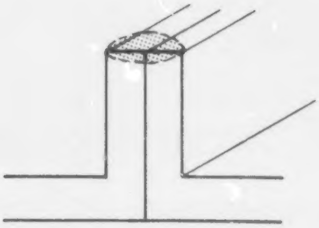
b. ____________________





d. ____________________

c. ____________________



e. ____________________

16. Name the four welding positions.

    a.

    b.

    c.

    d.

17. List four reasons for poor welds.

    a.

    b.

    c.

    d.

18. Demonstrate the ability to:

    a. Start, stop, and restart a bead.

    b. Construct a pad weld.

    c. Construct a butt weld.

    (NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

ARC WELDING
UNIT IV

ANSWERS TO TEST

1.
   a. 4
   b. 7
   c. 11
   d. 1
   e. 5
   f. 8
   g. 12
   h. 2
   i. 6
   j. 9
   k. 13
   l. 3
   m. 10

2. Any five of the following:
   a. Do not look at the arc without eye protection
   b. Wear a head or face shield that is in good condition
   c. Wear suitable clothing to protect all parts of the body
   d. Do not strike an arc or weld until you are sure those in the vicinity have protective equipment or will look the other direction
   e. Do not weld around combustible or flammable materials
   f. Do not pick up hot metal
   g. Do not weld in confined places without proper ventilation
   h. Open main switch or disconnect plug when checking a welder
   i. Do not leave electrode holder on welding table or in direct contact with grounded metal
   j. Do not use worn or frayed cables
   k. Stand on dry footing when welding
   l. Keep areas around welder clean
   m. Keep tools and metals in proper location
   n. Others as added by the instructor

3. Any two of the following:
   a. AC or alternating current
   b. DC or direct current
   c. Motor generator
   d. Engine generator
   e. AC/DC transformer-rectifier
4. a, b, c, d, f, g, i
5. Any three of the following:
   a. Mild steel
   b. High carbon steel
   c. Hard surfacing
   d. Low hydrogen
   e. Alloy
6. b, c, e, f
7. a. E--Electric arc welding
   b. 60--Tensile strength deposited in thousand pounds per square inch
   c. 1--Welding position; all positions
   d. 1--Special characteristics and usability of electrode
8. a, b, d, f, h, i
9. Any four of the following:
   a. Base metal strength properties
   b. Base metal composition
   c. Welding position
   d. Welding current
   e. Joint design and fit-up
   f. Thickness and shape of base metal
   g. Production efficiency and job conditions

10. Description should include:
    - a. Raising the current produces more heat
    - b. Lowering the current produces less heat
11. a. Scratching
    - b. Tapping
12. c, d
13. a. Slag
    - b. Weld
    - c. Gaseous shield
    - d. 15° - 30° angle of electrode
    - e. Electrode
    - f. Wire core
    - g. Coating (flux)
    - h. Arc
    - i. Heat lines
    - j. Base metal
    - k. Penetration
    - l. Direction of travel
    - m. Crater
14. a. Fillet
    - b. Groove
    - c. Bead
15. a. Butt
    - b. Corner
    - c. T
    - d. Lap
    - e. Edge

16. a. Flat

b. Horizontal

c. Vertical

d. Overhead

17. Any four of the following:

a. Machine adjustment too hot or too cool

b. Electrode size too large or too small

c. Improper movement of electrode

d. Improper angle of electrode

e. Improper base metal preparation

f. Arc length too long or too short

g. Others as added by instructor

18. Performance skills evaluated to the satisfaction of the instructor

OXYACETYLENE CUTTING
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to set up, light, adjust, and turn off an oxyacetylene cutting outfit following the proper order and safety precautions. The student should be able to make ninety-degree cuts on mild steel and cut round stock. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with oxyacetylene cutting to the correct definitions.
2. Identify the parts of an oxyacetylene cutting outfit.
3. Identify the parts of a torch body and cutting attachment.
4. List rules for safe handling of oxygen and acetylene equipment.
5. Identify the types of oxyacetylene cutting flames.
6. List reasons for poor cuts.
7. Select from a list causes of a backfire.
8. Describe what happens when a backfire occurs.
9. Describe what happens when a flashback occurs.
10. List in the proper order the steps to follow in case of a flashback.
11. Demonstrate the ability to:
    a. Set up equipment for oxyacetylene cutting.
    b. Turn on, light, adjust to a neutral flame, and turn off oxyacetylene cutting equipment.
    c. Make ninety-degree cuts on mild steel and restart a cut.
    d. Cut round stock.

OXYACETYLENE CUTTING
UNIT V

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information sheet.
- F. Secure color flame charts showing types of flames from welding supplier.
- G. Obtain film from local welding supplier to show various techniques in cutting.
- H. Demonstrate and discuss procedures outlined in the job sheets.
- I. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Demonstrate the ability to accomplish the procedures outlined in the job sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet

C. Transparency masters

1. TM 1--Oxyacetylene Cutting Outfit
2. TM 2--Parts of a Torch Body and Cutting Attachment
3. TM 3--Types of Oxyacetylene Cutting Flames

D. Job sheets

1. Job Sheet #1--Set Up Equipment for Oxyacetylene Cutting
2. Job Sheet #2--Turn On, Light, Adjust, and Turn Off the Cutting Torch
3. Job Sheet #3--Make Ninety-Degree Cuts on Mild Steel and Restart a Cut
4. Job Sheet #4--Cut Round Stock

E. Test

F. Answers to test

II. References:

A. Althouse, Andrew D.; Turnquist, Carl H.; and Bowditch, William A. *Modern Welding.* Homewood, Illinois: The Goodheart Willcox Co., 1970.

B. Phipps, Lloyd J.; McColly, H. F.; Scranton, L. L.; and Cook, G. C. *Farm Mechanics Text and Handbook.* Danville, Illinois: Interstate Printers and Publishers, Inc., 1964.

C. *Smith's Short Course for Gas Cutting, Welding, Brazing.* Minneapolis, Minnesota: Division of Tescom Corp./Education Department of Smith Welding Equipment.

D. *The Oxyacetylene Handbook: A Manual on Oxyacetylene Welding and Cutting Procedures.* New York: Linde Div./Union Carbide Corp., 1960.

E. Cowan, Earl; Braker, Clifton R.; Penner, Wayman; and Patton, Bob. *Welding.* Stillwater: Oklahoma State Department of Vocational and Technical Education, 1974.

III. Safety charts--"Smith's Safety Tips." Nos. 1-4. Available to Oklahoma instructors from MIDEKE Supply Co., 100 East Main, Oklahoma City, Oklahoma or from any Smith welding supply dealer.

OXYACETYLENE CUTTING
UNIT V

INFORMATION SHEET

I. Terms and definitions

   A. Flashback--Fire inside of the torch

      (CAUTION: This is a very dangerous condition.)

   B. Backfire--Momentary burning back of the flame into the tip

   C. Flame cutting--Process by which iron or steel is heated to a temperature where it can be rapidly oxidized by high purity oxygen flowing under pressure through a cutting torch

      (NOTE: As the metal is oxidized, the preheat flame maintains the temperature necessary to keep the oxidation process going in a narrow zone across the length of the base metal.)

   D. Slag box--Metal container with a layer of water or sand to catch hot slag

      (NOTE: Slag is the metal which melts away during the oxyacetylene cutting process.)

   E. Dragline--Situation in which the most distant portion of the cutting stream lags behind the stream nearest the cutting tip

   F. Kerf--Area of material removed from a piece of metal by a saw or cutting torch

   G. Oxide--Substance that is produced when oxygen is combined with an element

      Examples: Rust, corrosion, coating, film, or scale

   H. Oxidizing--Combining oxygen with another substance

      Example: A metal is oxidized when the metal is cut

   I. Purge--To remove any foreign material from a system or component by flushing with the gas used in that system

II. Parts of an oxyacetylene cutting outfit (Transparency 1)

   A. Oxygen cylinder

   B. Oxygen regulator

INFORMATION SHEET

C. Oxygen pressure regulating screw

D. Oxygen cylinder valve

E. Acetylene cylinder

F. Acetylene regulator

G. Acetylene pressure regulating screw

H. Acetylene cylinder valve

I. Safety chain

J. Cylinder truck

K. Oxygen hose

(NOTE: The color code for oxygen is green.)

L. Acetylene hose

(NOTE: The color code for acetylene is red.)

M. Oxygen fitting

(NOTE: The oxygen fitting has right-hand threads.)

N. Acetylene fitting

(NOTE: The acetylene fitting has left-hand threads with a grooved nut.)

O. Oxygen torch valve

P. Torch body

Q. Acetylene torch valve

R. Cutting attachment

S. Oxygen preheat valve

T. Oxygen cutting lever

U. Tip

V. Tip nut

INFORMATION SHEET

III. Parts of the torch body and cutting attachment (Transparency 2)

A. Cutting torch

1. Oxygen fitting
2. Acetylene fitting
3. Oxygen torch valve
4. Acetylene torch valve
5. Torch body
6. Oxygen cutting lever
7. Oxygen preheat valve
8. Tip nut
9. Tip

B. Cutting tip

(NOTE: The selection of the correct tip for the job is determined by the thickness of metal, the size of tip orifice, and the oxygen cutting pressures. See manufacturer's recommendations.)

1. Preheat orifice

   (NOTE: The preheat orifice heats metal to kindling point of approximately 1600°F or 755°C.)

2. Cutting orifice

   (NOTE: The cutting orifice removes oxidized metal.)

IV. Rules for safe handling of oxygen and acetylene equipment

A. Secure cylinders to prevent damage to valves or regulators

B. Purge cylinder valve before attaching regulators

C. Release adjusting screws on regulator before opening cylinder valve

D. Stand to one side of regulator while slowly opening the cylinder valve

INFORMATION SHEET

E. Do not use acetylene at pressures higher than 15 psi

(NOTE: Acetylene becomes unstable at pressures higher than 15 psi and becomes highly explosive.)

F. Purge oxygen and acetylene passages before lighting torch

G. Light acetylene gas before opening oxygen valve on torch

H. Do not use oil on regulators, torches, fittings, or any place that it may come in contact with oxygen

(NOTE: Oil or grease and oxygen have a very great attraction for one another and will unite with explosive violence.)

I. Do not use oxygen as a substitute for compressed air

J. Keep heat, flames, and sparks away from combustibles

K. Use safety goggles, gloves, and protective clothing

(NOTE: Keep gloves, hands, and clothing free from oil and grease.)

L. Test connections for leaks with Ivory soap suds and paintbrush

M. Do not weld on containers that have been used for combustible materials

N. Avoid breathing toxic fumes when welding

Example: Galvanized metal

O. Do not leave a burning torch unattended

P. Do not cut or weld near concrete

Q. Operate torch in a well-ventilated place

R. Weld or cut at least five feet from cylinders

S. Protect hoses from hot metal, rupture, or mechanical damage

(NOTE: Instructor may add other safety rules.)

V. Types of oxyacetylene cutting flames (Transparency 3)

A. Carburizing flame

(NOTE: The flame has an excess of acetylene gas.)

INFORMATION SHEET

B. Neutral flame

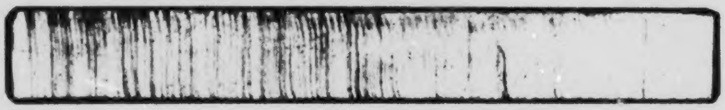
(NOTE: The flame has the proper ratio of oxygen to acetylene.)

C. Oxidizing flame

(NOTE: There is an excess of oxygen.)

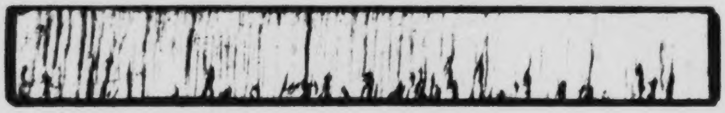
VI. Reasons for poor cuts

(NOTE: This is a correctly made cut in one-inch plate. The edge is square and the draglines are essentially vertical and not too pronounced.)



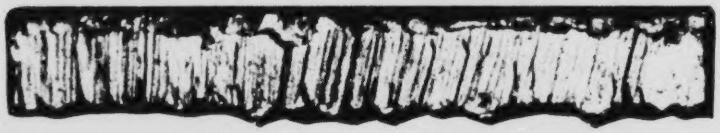
A. Preheat flames too small

(NOTE: The cutting speed was too slow, causing bad gouging at the bottom.)



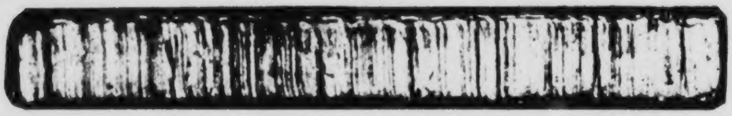
B. Preheat flames too long

(NOTE: The top surface has melted over, the cut edge is irregular, and there is an excessive amount of adhering slag.)



C. Oxygen pressure too low

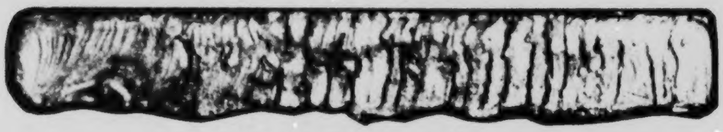
(NOTE: The top edge has melted over because the cutting speed was too slow.)



INFORMATION SHEET

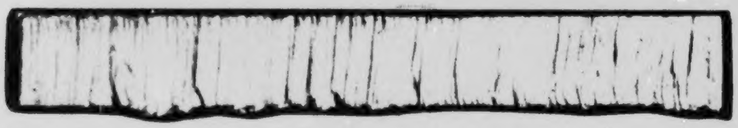
D. Oxygen pressure too high; nozzle size too small

(NOTE: The entire control of the cut has been lost.)



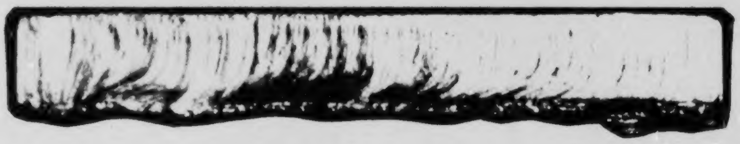
E. Cutting speed too slow

(NOTE: The irregularities of the draglines are emphasized.)



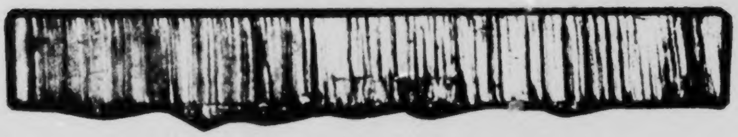
F. Cutting speed too fast

(NOTE: There is a pronounced break to the dragline and the cut edge is irregular.)



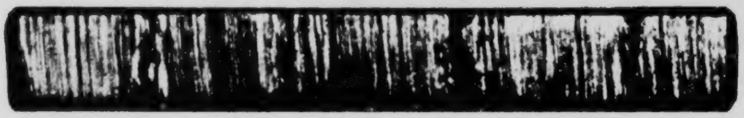
G. Blowpipe travel unsteady

(NOTE: The cut edge is wavy and irregular.)



H. Cut lost and not carefully restarted

(NOTE: Bad gouges were caused at the restarting point.)



VII. Causes of a backfire

A. Insufficient acetylene or oxygen pressure

B. Loose cutting tip

INFORMATION SHEET

C. Dirty tip

D. Overheating of cutting tip

E. Bad "O" ring in torch body

(NOTE The above causes should be carefully checked to control backfire.)

VIII. What happens when a backfire occurs

A. Flame burns momentarily back into tip

B. A loud snap or pop is emitted from the torch

C. Flame either goes out or continues to burn in normal manner

IX. What happens when a flashback occurs

A. Flame disappears inside the torch body

B. Squealing noise, smoke, and/or sparks are emitted from the torch tip

X. Steps to follow in case of a flashback

A. Close oxygen preheat valve

B. Close oxygen torch valve

C. Close acetylene torch valve

D. Release oxygen regulator screw

E. Release acetylene regulator screw

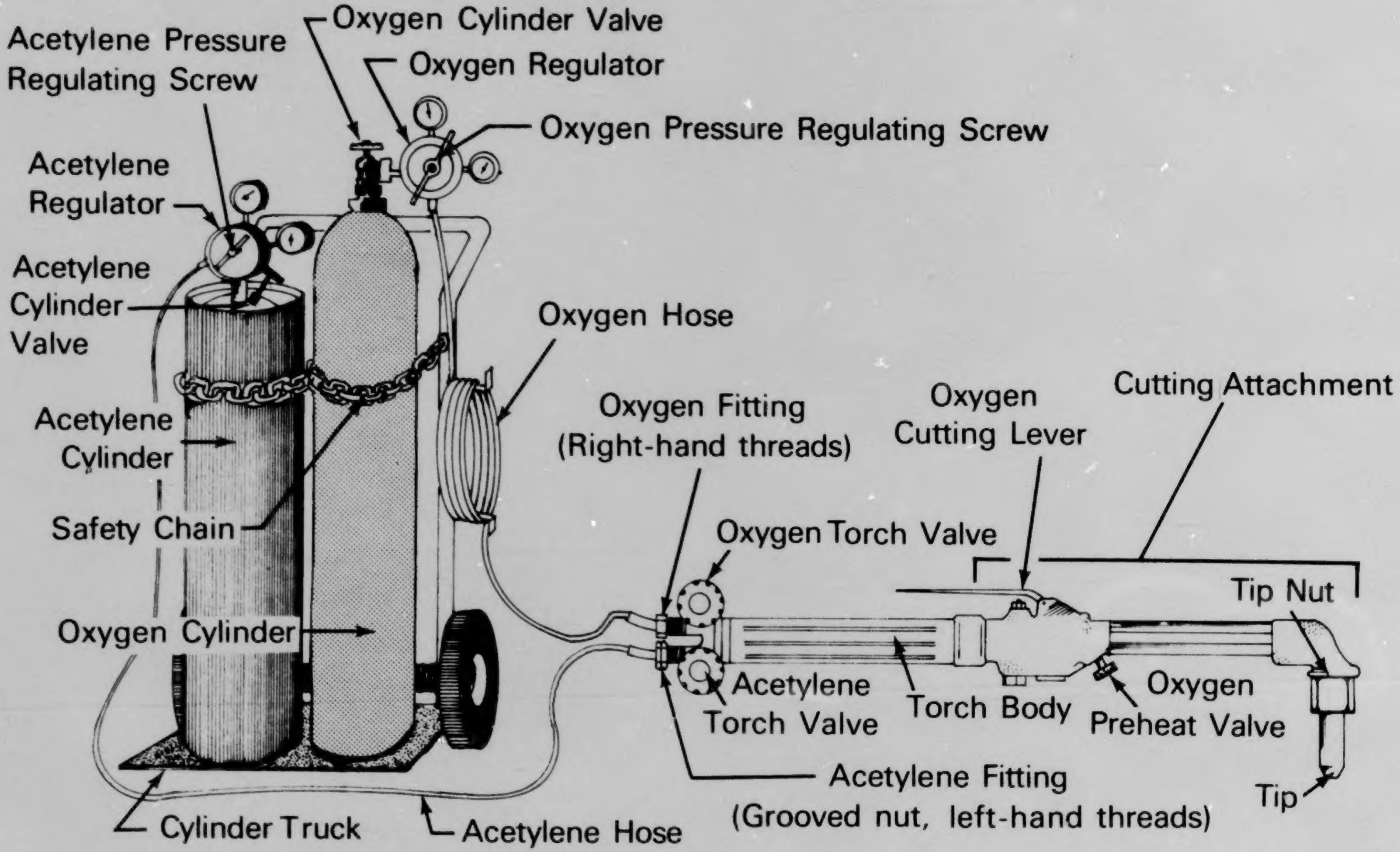
F. Examine acetylene unit

G. Reset regulator pressures

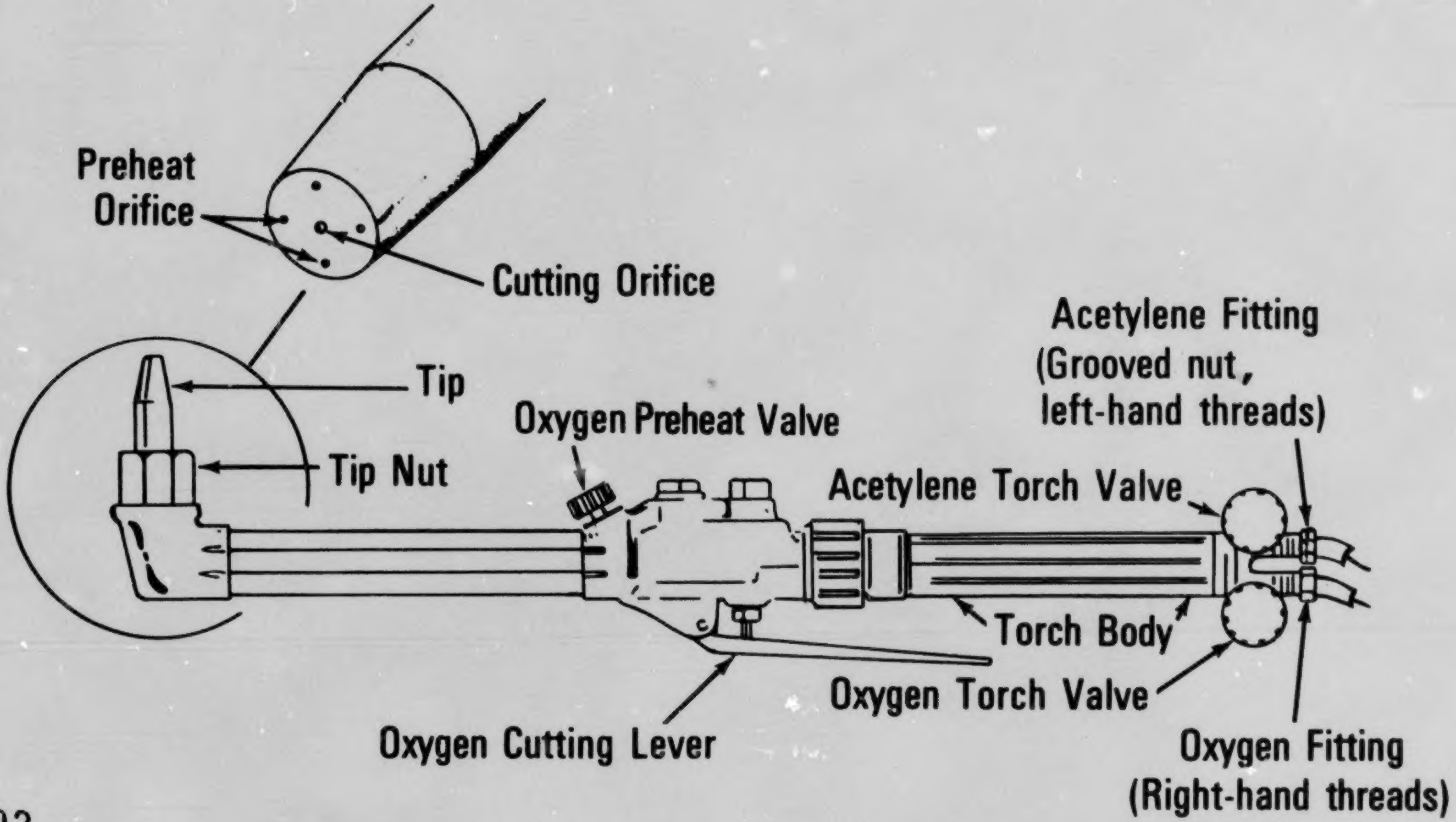
H. Light torch

(NOTE: If heavy smoke comes out of the torch tip and the torch body becomes hot, the flashback has probably traveled past the mixing chamber into the hose. In this case, shut off the oxygen cylinder valve and the acetylene cylinder valve and then notify the instructor.)

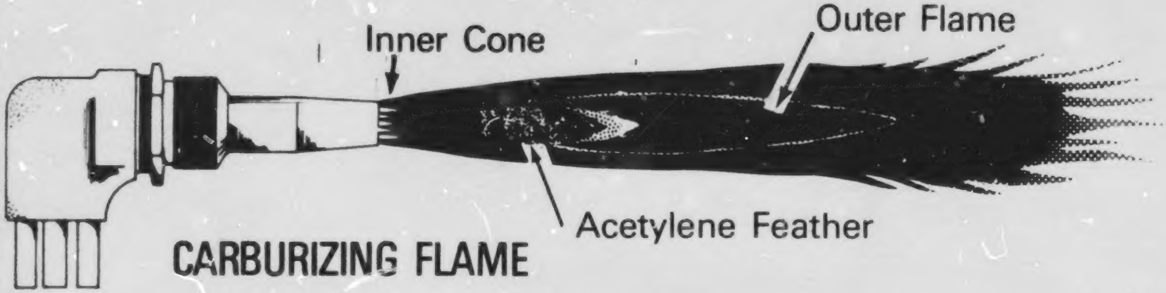
Oxyacetylene Cutting Outfit


Oxygen Cylinder Valve
Acetylene Pressure Regulating Screw
Oxygen Regulator
Oxygen Pressure Regulating Screw
Acetylene Regulator
Acetylene Cylinder Valve
Oxygen Hose
Acetylene Cylinder
Safety Chain
Oxygen Fitting (Right-hand threads)
Oxygen Cutting Lever
Cutting Attachment
Oxygen Torch Valve
Tip Nut
Oxygen Cylinder
Acetylene Torch Valve
Torch Body
Oxygen Preheat Valve
Acetylene Fitting (Grooved nut, left-hand threads)
Tip
Cylinder Truck
Acetylene Hose

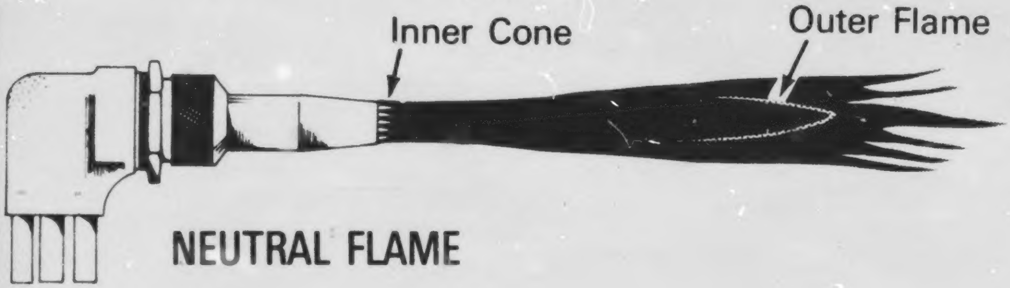
Parts of a Torch Body and Cutting Attachment


Preheat Orifice
Cutting Orifice
Tip
Tip Nut
Oxygen Preheat Valve
Acetylene Fitting (Grooved nut, left-hand threads)
Acetylene Torch Valve
Torch Body
Oxygen Torch Valve
Oxygen Cutting Lever
Oxygen Fitting (Right-hand threads)

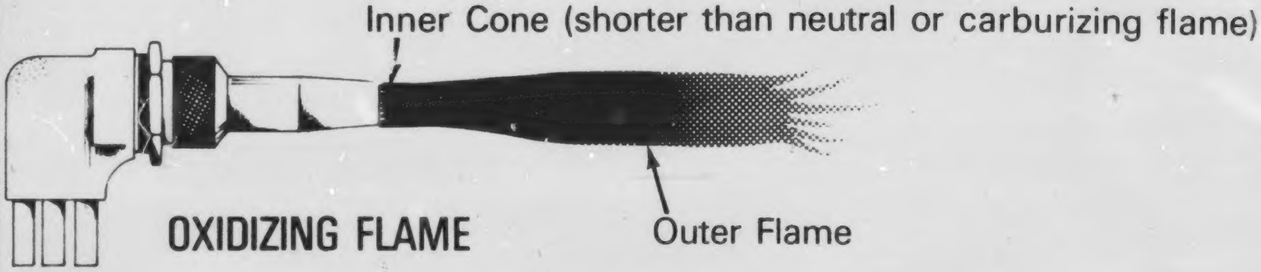
Types of Oxyacetylene Cutting Flames


Inner Cone
Outer Flame
Acetylene Feather

CARBURIZING FLAME


Inner Cone
Outer Flame

NEUTRAL FLAME


Inner Cone (shorter than neutral or carburizing flame)
Outer Flame

OXIDIZING FLAME

AM I - 235-A

OXYACETYLENE CUTTING
UNIT V

JOB SHEET #1--SET UP EQUIPMENT FOR OXYACETYLENE CUTTING

I. Tools and materials

   A. Oxygen cylinder

   B. Acetylene cylinder

   C. Oxygen regulator

   D. Acetylene regulator

   E. Hoses

   F. Wrench

   G. Cylinder holder

   H. Water container

   I. Ivory soap suds

   J. Clean paintbrush

   K. Torch body with tips

II. Procedure

   A. Fasten cylinders in a vertical position

   B. Remove caps from cylinders

   C. Crack valves of each cylinder to remove foreign material; close valves

   D. Connect oxygen regulator to oxygen cylinder

   (CAUTION: Do not use oil on any connections on the oxyacetylene system.)

      1. Turn adjusting screw on regulator counterclockwise until tension on spring is released

      2. Turn cylinder valve wide open slowly

JOB SHEET #1

E. Connect acetylene regulator to acetylene cylinder

   1. Turn adjusting screw on regulator counterclockwise until tension on spring is released

   2. Open cylinder valve 1/2 to 3/4 of a turn

      (NOTE: Never open cylinder valve more than 1 1/2 turns.)

F. Connect acetylene hose to acetylene regulator; purge hose

G. Connect oxygen hose to oxygen regulator; purge hose

H. Connect torch body to oxygen and acetylene hoses

I. Close both valves on torch body

J. Attach cutting attachment to torch body

   (NOTE: The tip size is determined by the thickness of metal to be cut and the manufacturer's recommendations.)

K. Close oxygen preheat valve on cutting attachment

L. Turn adjusting screw on oxygen regulator clockwise until working pressure is reached

M. Turn adjusting screw on acetylene regulator clockwise until correct working pressure is reached

N. Test all connections for leaks with Ivory soap suds and water

   (NOTE: Apply soap suds with a clean paintbrush.)

OXYACETYLENE CUTTING
UNIT V

JOB SHEET #2--TURN ON, LIGHT, ADJUST, AND TURN OFF THE CUTTING TORCH

I. Tools and materials

  A. Oxyacetylene cutting outfit

  B. Wrench

  C. Gloves

  D. Safety goggles

  E. Coveralls or protective clothing

II. Procedure for turning on, lighting, and adjusting the cutting torch to a neutral flame

  A. Check all cylinder, regulator, and torch valves to make sure they are closed

  B. Open acetylene cylinder valve 1/2 to 3/4 of a turn

  (NOTE: Never open cylinder valve more than 1 1/2 turns.)

  C. Open acetylene valve on torch one turn

  D. Turn adjusting screw on acetylene regulator clockwise until desired pressure is reached

  (NOTE: Oxygen and acetylene pressures and size of tip depend upon the thickness of metal to be cut. Use pressures and tip size recommended by manufacturer.)

  E. Close acetylene valve on torch

  F. Open oxygen cylinder valve all the way

  G. Open oxygen torch valve all the way

  H. Open oxygen preheat valve on cutting attachment one turn

  I. Turn adjusting screw on oxygen regulator clockwise until desired pressure is reached

  J. Close oxygen preheat valve on cutting attachment

  K. Open acetylene valve on torch 1/4 turn

JOB SHEET #2

L. Light the torch with flint lighter and adjust until smoke on flame clears

M. Open oxygen preheat valve slowly and adjust to a neutral flame

N. Depress the oxygen cutting lever and check to see that a neutral flame is present

(NOTE: If necessary, adjust the oxygen preheat valve with the oxygen cutting lever depressed until a neutral flame is secured.)

III. Procedure for turning off the flame and oxyacetylene unit

A. Close acetylene valve on torch

B. Close oxygen preheat valve

C. Close acetylene cylinder valve

D. Close oxygen cylinder valve

E. Open acetylene valve on torch

(NOTE: When gauges reach 0, close torch valve and release adjusting screw on acetylene regulator by turning counterclockwise.)

F. Open oxygen preheat valve on torch

(NOTE: When gauges reach 0, close oxygen preheat valve and release adjusting screw on oxygen regulator by turning counterclockwise.)

G. Close oxygen valve on torch

H. Place torch and hose on hanger or brackets provided

OXYACETYLENE CUTTING
UNIT V

JOB SHEET #3--MAKE NINETY-DEGREE CUTS ON MILD STEEL AND RESTART A CUT

I. Tools and materials

   A. Cutting outfit

   B. Mild steel plate 1/4" to 1/2" thick, 4" wide or wider, 8" long or longer

   C. Soapstone with a sharp point or edge

   D. Straightedge

   E. Gloves

   F. Safety goggles

   G. Pliers

   H. Coveralls

   I. Flint lighter

   J. Welding or cutting table

   K. Slag box

   L. Can of water

   M. Cutting tip

II. Procedure

   A. Mark four parallel lines 2" apart on plate to be cut

   B. Adjust oxygen regulator

   C. Adjust acetylene regulator

   D. Place plate over slag box

   E. Light torch

   F. Adjust to neutral flame

   G. Assume comfortable position

JOB SHEET #3

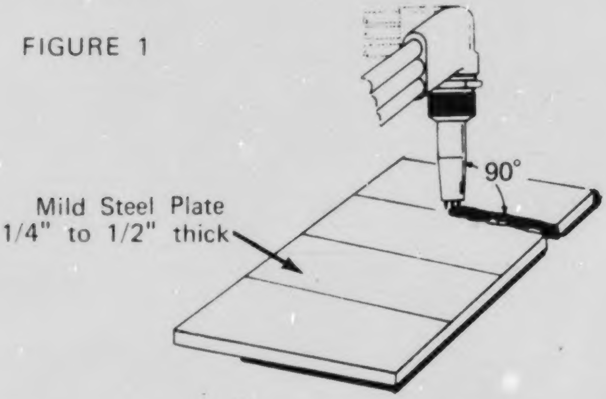
H. Place hoses behind you

I. Maneuver torch with both hands

J. Hold preheat flame with tip of inner cone 1/16" to 1/8" above top of plate at right edge until red spot appears

K. Depress the oxygen cutting lever and move from right to left across the plate (Figure 1)

FIGURE 1



L. Hold the tip at right angle to work while cutting with inner cone being 1/16" to 1/8" above work

M. Make 90° cuts until you have developed the proper procedure

N. Cool metal by placing in can of water with the aid of pliers

O. Show samples to instructor for approval and grading

III. Procedure for restarting a cut

A. Release the oxygen cutting lever

B. Preheat edge only where cutting action was stopped

C. Depress oxygen cutting lever slowly and continue cut

OXYACETYLENE CUTTING
UNIT V

JOB SHEET #4--CUT ROUND STOCK

I. Tools and materials

   A. Cutting outfit

   B. Pieces of reinforcing bar, 1/2", 5/8", 3/4", or 1"

   C. Soapstone with sharp point or edge

   D. Tape

   E. Gloves

   F. Safety goggles

   G. Pliers

   H. Coveralls

   I. Flint lighter

   J. Welding or cutting table

   K. Slag box

   L. Can of water

   M. Cutting tip

II. Procedure

   A. Mark reinforcing bar to desired length

   B. Adjust oxygen and acetylene regulators

   C. Place area to be cut over slag box

   D. Light torch

   E. Adjust to neutral flame

   F. Assume comfortable position

   G. Place hoses behind you

   H. Maneuver torch with both hands

JOB SHEET #4

I. Hold preheat flame with tip of inner cone 1/16" to 1/8" above edge of reinforcing bar until it becomes red

J. Depress the cutting lever and rotate torch tip into the direction of travel until rod is cut (Figure 1)

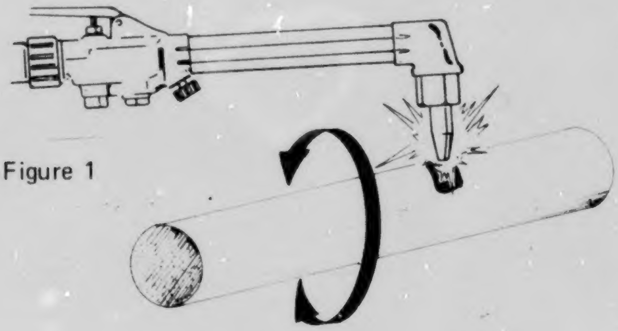


Figure 1

K. Repeat the procedure for each bar or rod

OXYACETYLENE CUTTING
UNIT V

TEST

1. Match the terms on the right to the correct definitions.

______a. Fire inside of the torch

______b. Momentary burning back of the flame into the tip

______c. Process by which iron or steel is heated to a temperature where it can be rapidly oxidized by high purity oxygen flowing under pressure through a cutting torch

______d. Metal container with a layer of water or sand to catch hot slag

______e. Situation in which the most distant portion of the cutting stream lags behind the stream nearest the cutting tip

______f. Combining oxygen with another substance

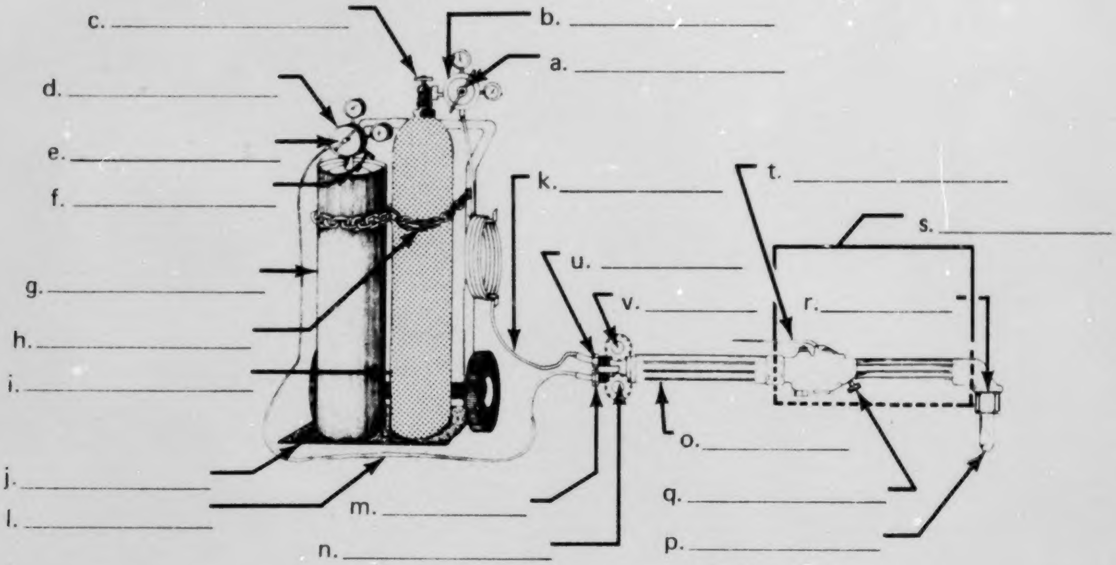
______g. Substance that is produced when oxygen is combined with an element

______h. Area of material removed from a piece of metal by a saw or cutting torch

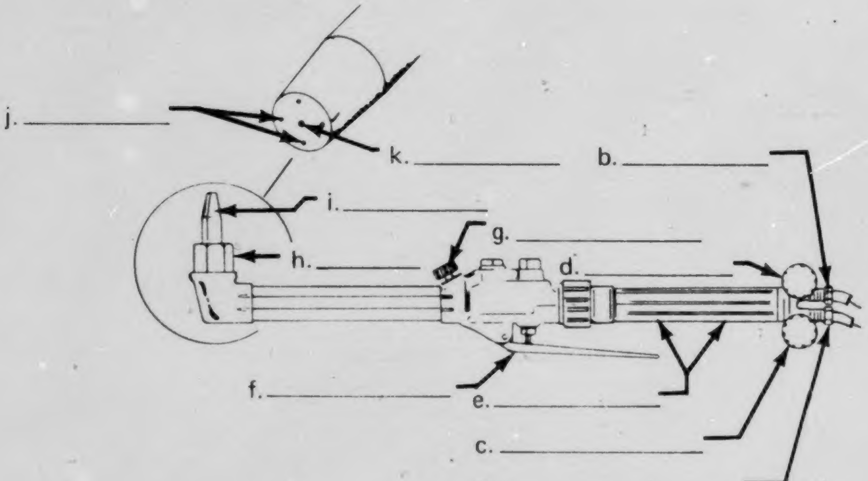
______i. To remove any foreign material from a system or component by flushing with the gas used in that system

1. Slag box
2. Oxidizing
3. Flashback
4. Dragline
5. Oxide
6. Backfire
7. Kerf
8. Purge
9. Flame cutting

2. Identify the parts of the oxyacetylene cutting outfit in the diagram below by writing the correct names in the blanks.


c. ____
b. ____
a. ____
d. ____
e. ____
f. ____
k. ____
t. ____
s. ____
u. ____
g. ____
v. ____
r. ____
h. ____
i. ____
o. ____
j. ____
q. ____
m. ____
l. ____
p. ____
n. ____

3. Identify the parts of the torch body and cutting attachment in the diagram below.


j. ____
k. ____
b. ____
i. ____
g. ____
h. ____
d. ____
f. ____
e. ____
c. ____
a. ____

4. List eight rules for the safe handling of oxygen and acetylene equipment.

   a.

   b.

   c.

   d.

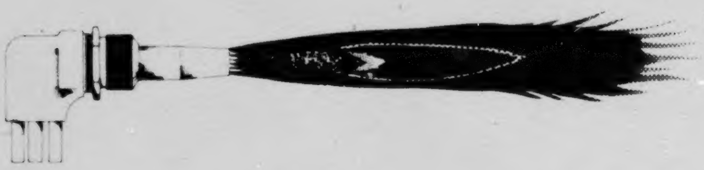
   e.

   f.

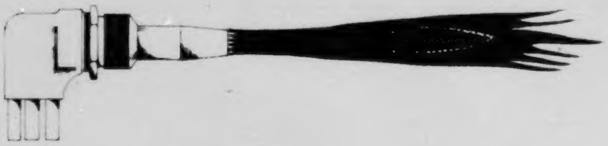
   g.

   h.

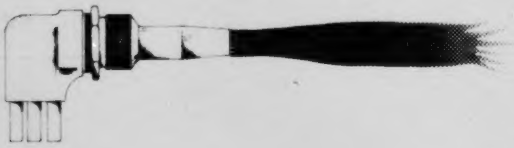
5. Identify the following three types of flames.



a. ____



b. ____



c. ____

6. List five reasons for poor cuts.

a.

b.

c.

d.

e.

7. Select from the list below the causes of a backfire by placing an "X" in the blanks.

______a. Too much oxygen

______b. Insufficient acetylene or oxygen pressure

______c. Too much acetylene

______d. Loose cutting tip

______e. Overheating of cutting tip

______f. Bad "O" ring in torch body

______g. Dirty tip

8. Describe what happens when a backfire occurs.

9. Describe what happens when a flashback occurs.

10. List in the proper order the steps to follow in case of a flashback.

    a.

    b.

    c.

    d.

    e.

    f.

    g.

    h.

11. Demonstrate the ability to:

    a. Set up equipment for oxyacetylene cutting.

    b. Turn on, light, adjust to a neutral flame, and turn off oxyacetylene cutting equipment.

    c. Make ninety-degree cuts on mild steel and restart a cut.

    d. Cut round stock.

    (NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

OXYACETYLENE CUTTING
UNIT V

ANSWERS TO TEST

1. a. 3
   b. 6
   c. 9
   d. 1
   e. 4
   f. 2
   g. 5
   h. 7
   i. 8

2. a. Oxygen pressure regulating screw
   b. Oxygen regulator
   c. Oxygen cylinder valve
   d. Acetylene regulator
   e. Acetylene pressure regulating screw
   f. Acetylene cylinder valve
   g. Acetylene cylinder
   h. Safety chain
   i. Oxygen cylinder
   j. Cylinder truck
   k. Oxygen hose
   l. Acetylene hose
   m. Acetylene fitting
   n. Acetylene torch valve
   o. Torch body
   p. Tip
   q. Oxygen preheat valve
   r. Tip nut

s. Cutting attachment

t. Oxygen cutting lever

u. Oxygen fitting

v. Oxygen torch valve

3. a. Oxygen fitting

b. Acetylene fitting

c. Oxygen torch valve

d. Acetylene torch valve

e. Torch body

f. Oxygen cutting lever

g. Oxygen preheat valve

h. Tip nut

i. Tip

j. Preheat orifice

k. Cutting orifice

4. Any eight of the following:

a. Secure cylinders to prevent damage to valves or regulators

b. Purge cylinder valve before attaching regulators

c. Release adjusting screws on regulator before opening cylinder valve

d. Stand to one side of regulator while slowly opening the cylinder valve

e. Do not use acetylene at pressures higher than 15 psi

f. Purge oxygen and acetylene passages before lighting torch

g. Light acetylene gas before opening oxygen valve on torch

h. Do not use oil on regulators, torches, fittings, or any place that it may come in contact with oxygen

i. Do not use oxygen as a substitute for compressed air

j. Keep heat, flames, and sparks away from combustibles

k. Use safety goggles, gloves, and protective clothing

l. Test connections for leaks with Ivory soap suds and paintbrush

m. Do not weld on containers that have been used for combustible materials

n. Avoid breathing toxic fumes when welding

o. Do not leave a burning torch unattended

p. Do not cut or weld near concrete

q. Operate torch in a well-ventilated place

r. Weld or cut at least five feet from cylinders

s. Protect hoses from hot metal, rupture, or mechanical damage

t. Others as added by instructor

5. a. Carburizing

   b. Neutral

   c. Oxidizing

6. Any five of the following:

   a. Preheat flames too small

   b. Preheat flames too long

   c. Oxygen pressure too low

   d. Oxygen pressure too high; nozzle size too small

   e. Cutting speed too slow

   f. Cutting speed too fast

   g. Blowpipe travel unsteady

   h. Cut lost and not carefully restarted

7. b, d, e, f, g

8. Description should include:

   a. Flame burns momentarily back into tip

   b. A loud snap or pop is emitted from the torch
   c. Flame either goes out or continues to burn in normal manner

9. Description should include:
   a. Flame disappears inside the torch body
   b. Squealing noise, smoke, and/or sparks are emitted from the torch tip

10. a. Close oxygen preheat valve
    b. Close oxygen torch valve
    c. Close acetylene torch valve
    d. Release oxygen regulator screw
    e. Release acetylene regulator screw
    f. Examine acetylene unit
    g. Reset regulator pressures
    h. Light torch

11. Performance skills evaluated to the satisfaction of the instructor

OXYACETYLENE FUSION WELDING
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to demonstrate the ability to light, adjust, and turn off the oxyacetylene welding equipment; handle the equipment properly; and make welds with or without filler rod. The student should be able to select proper tip size and list factors that determine the correct type of filler rod to use. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with oxyacetylene fusion welding to the correct definitions.
2. Identify the parts of oxyacetylene fusion welding equipment.
3. Select from a list factors that determine weld quality.
4. List properties of a good weld.
5. Select from a list factors that determine tip size in oxyacetylene welding.
6. List factors that determine the type of filler rod to use in oxyacetylene welding.
7. State in writing the purpose of a filler rod.
8. Identify types of oxyacetylene fusion welding flames.
9. Demonstrate the ability to:
    a. Turn on, light, adjust, and turn off the oxyacetylene welding equipment.
    b. Construct a corner weld without filler rod.
    c. Lay beads on gauge metal without filler rod.
    d. Lay beads on gauge metal with filler rod.
    e. Weld butt joints with filler rod.

OXYACETYLENE FUSION WELDING
UNIT VI

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Demonstrate and discuss procedures outlined in the job sheets.

  (NOTE: The instructor may want to secure films on oxyacetylene fusion welding from the Curriculum and Instructional Materials Center to show to the class.)

  G. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Demonstrate the ability to accomplish the procedures outlined in the job sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Oxyacetylene Welding Equipment

    2. TM 2--Welding Torches

3. TM 3--Welding Regulators

4. TM 4--Oxyacetylene Fusion Welding Flames

D. Job sheets

1. Job Sheet #1--Turn On, Light, Adjust, and Turn Off Oxyacetylene Welding Equipment

2. Job Sheet #2--Construct a Corner Weld Without a Filler Rod

3. Job Sheet #3--Lay Beads on Gauge Metal Without Filler Rod

4. Job Sheet #4--Lay Beads on Gauge Metal with Filler Rod

5. Job Sheet #5--Weld Butt Joints with Filler Rod

E. Test

F. Answers to test

II. References:

A. *Smith's Instructor's Manual for a Basic Course in Oxyacetylene Brazing, Cutting, and Welding.* Form 424. Minneapolis, Minnesota: Smith Welding Equipment/Divison of Tescom Corp.

B. *Instructor's Answer Key.* Form 429. For use with *Smith's Instructor's Manual* (Form 424). Minneapolis, Minnesota: Smith Welding Equipment/Division of Tescom Corp.

C. Phipps, Lloyd J.; McColly, H. F.; Scranton, L. L.; and Cook, G. C. *Farm Mechanics Text and Handbook.* Danville, Illinois: The Interstate Printers and Publishers, Inc.

D. Althouse, Andrew D.; Turnquist, Carl H.; and Bowditch, William A. *Modern Welding.* Homewood, Illinois: Goodheart-Willcox Co., Inc., 1965.

E. *The Oxyacetylene Handbook: A Manual on Oxyacetylene Welding and Cutting Procedures.* New York: Linde Div./Union Carbide Corp., 1960.

III. Films:

A. "Oxyacetylene Welding Equipment." Film Library, Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1515 West Sixth Street, Stillwater, Oklahoma 74074.

B. "Oxyacetylene Welding: Torch Techniques." Film Library, Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1515 West Sixth Street, Stillwater, Oklahoma 74074.

OXYACETYLENE FUSION WELDING
UNIT VI

INFORMATION SHEET

I. Terms and definitions

   A. Fusion welding--Joining of pieces of metal by heating the adjoining edges to the fusion or melting point and allowing them to flow or run together and then cool

   B. Penetration--Distance from the original surface of the base metal to that point at which fusion ceases

   C. Base metal--Metal to be welded

   D. Alloy--Mixture with metallic properties; composed of two or more elements of which at least one is a metal

   E. Inner cone--Inner white part of a neutral flame

   F. Tack weld--Short weld used for temporarily holding metal in place

   G. Backfire--Momentary burning back of the flame into the tip; flame goes out with a loud snap or pop

   H. Flashback--Fire inside the torch; indicated by a hissing or squealing sound

   (CAUTION: This is a very dangerous condition.)

II. Oxyacetylene welding equipment (Transparencies 1, 2, and 3)

   A. Acetylene cylinder

   B. Acetylene cylinder valve

   C. Acetylene fitting

   D. Acetylene regulator

   E. Oxygen cylinder

   F. Oxygen cylinder valve

   G. Oxygen fitting

   H. Oxygen regulator

   I. Oxygen torch valve

   J. Torch body

   K. Acetylene torch valve

INFORMATION SHEET

- L. Welding tip
- M. Welding goggles
- N. Welding gloves
- O. Safety chain
- P. Flint lighter
- Q. Cylinder truck
- R. Oxygen hose
- S. Acetylene hose

III. Factors that determine weld quality

- A. Proper flame adjustment
- B. Angle of tip
- C. Distance from work
- D. Speed of travel
- E. Movement of tip

IV. Properties of a good weld

- A. Consistent width
- B. Straightness
- C. Slightly crowned
- D. Fused into base metal
- E. Clean appearance

V. Factors that determine tip size

- A. Thickness of metal
- B. Size of welding rod

(NOTE: Always use manufacturer's recommendation on tip size.)

INFORMATION SHEET

VI. Factors that determine filler rod selection

   A. Rod with similar properties as base metal

   B. Thickness of metal

   (NOTE: A general rule is to use a rod with a diameter equal to the thickness of the base metal.)

VII. Purpose of filler rod--To add strength to weld or joint

VIII. Oxyacetylene welding flames (Transparency 4)

   A. Carburizing flame

   (NOTE: The flame contains an excess of acetylene and is identified by an acetylene feather visible on the inner cone. It is recommended for welding cast iron. Carbon is introduced into the weld, causing hardening of the metal.)

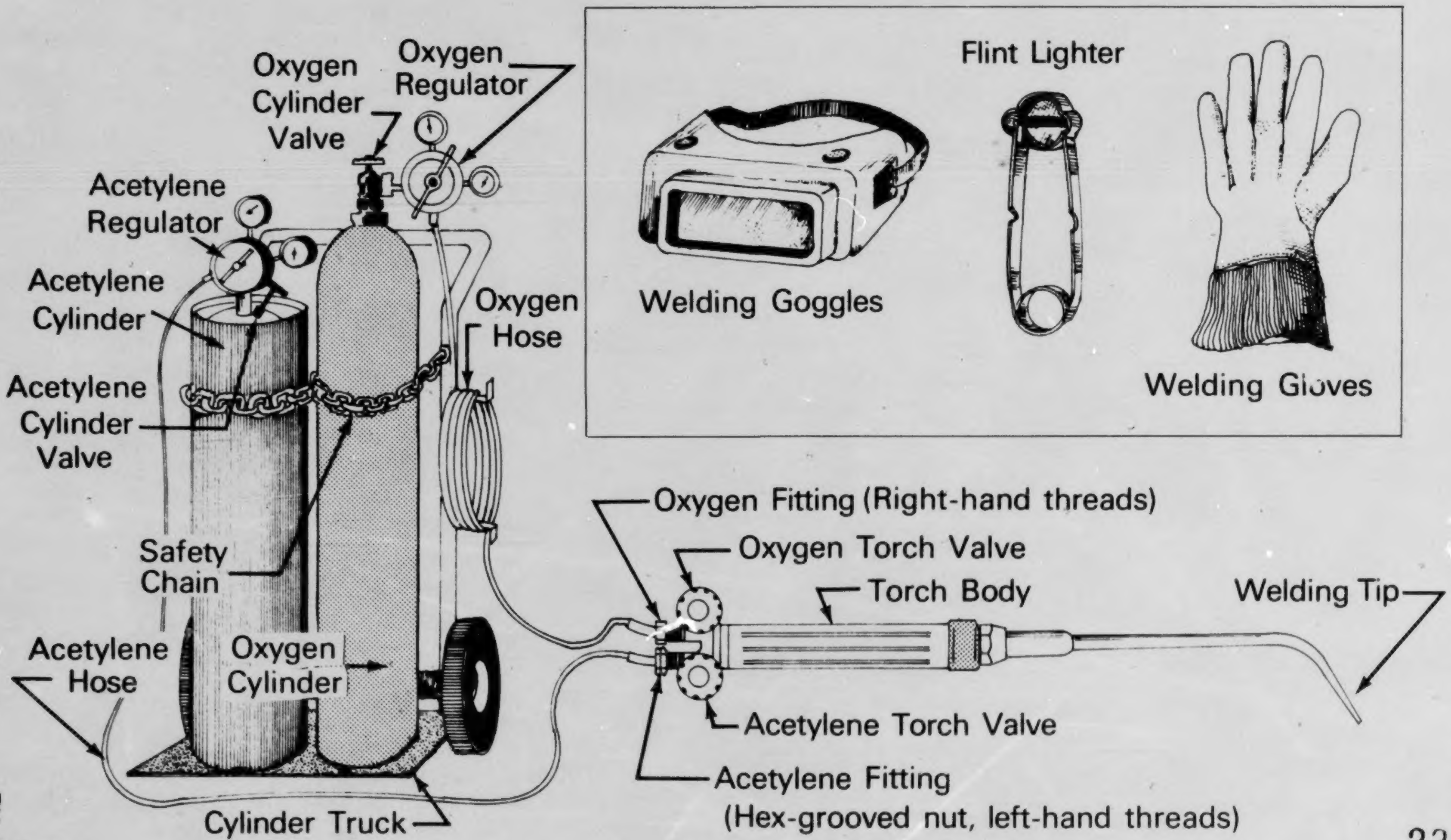
   B. Neutral flame

   (NOTE: The flame burns equal parts of oxygen and acetylene at a temperature of approximately 5950°F or 3270°C. It is identified by a clear, well-defined white inner cone.)

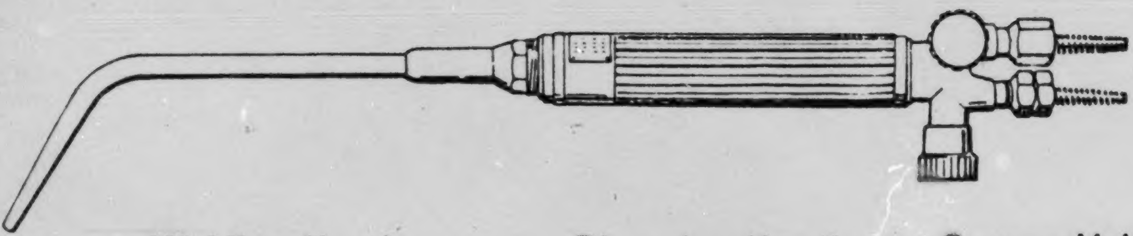
   C. Oxidizing flame

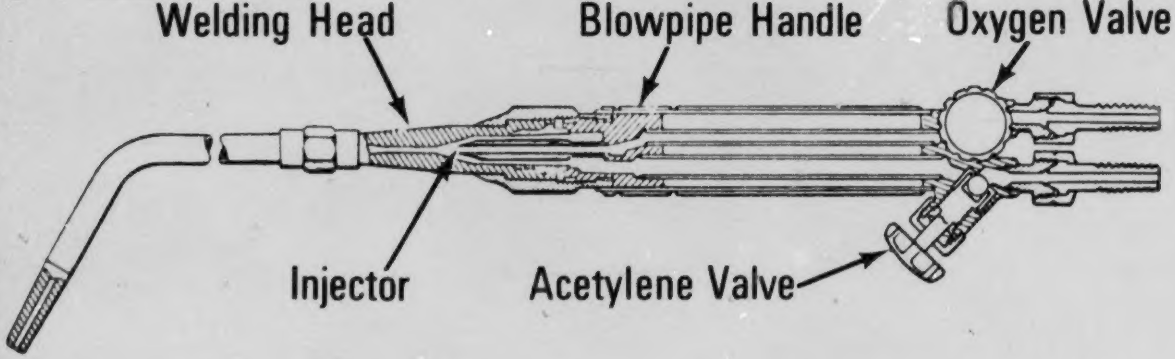
   (NOTE: The flame burns an excess of oxygen and is identified by a short inner cone. It is the hottest of the three types of welding flames. It oxidizes the metal, causing it to harden and become brittle, and is therefore not recommended for welding most metals. It is recommended for brazing when slightly oxidized.)

Oxyacetylene Welding Equipment

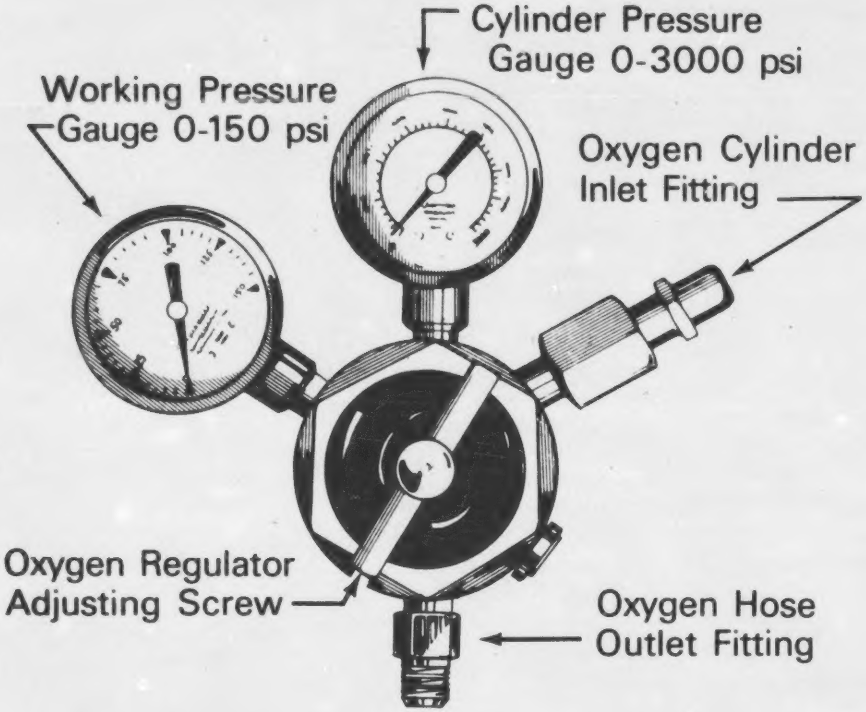

Oxygen Cylinder Valve
Oxygen Regulator
Acetylene Regulator
Acetylene Cylinder
Acetylene Cylinder Valve
Safety Chain
Oxygen Hose
Acetylene Hose
Oxygen Cylinder
Cylinder Truck
Flint Lighter
Welding Goggles
Welding Gloves
Oxygen Fitting (Right-hand threads)
Oxygen Torch Valve
Torch Body
Welding Tip
Acetylene Torch Valve
Acetylene Fitting
(Hex-grooved nut, left-hand threads)

Welding Torches

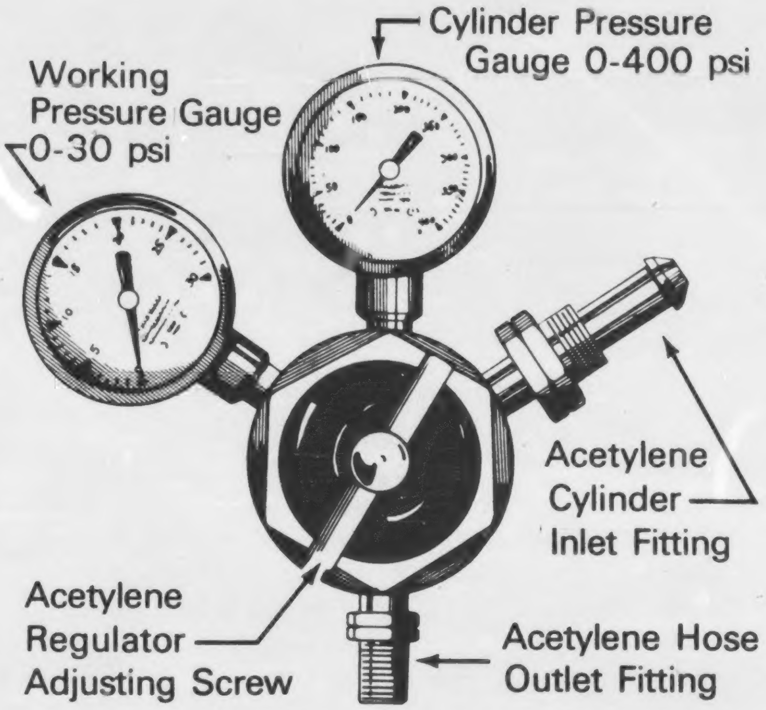



Welding Head
Blowpipe Handle
Oxygen Valve
Injector
Acetylene Valve

Welding Regulators

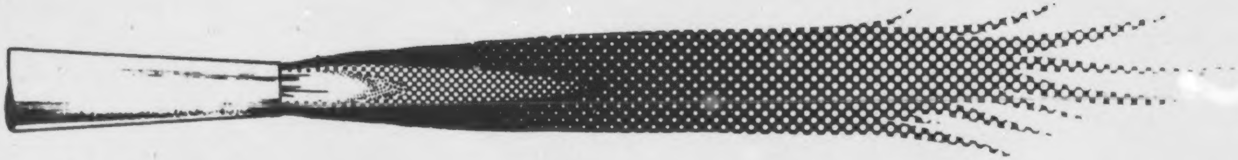

Cylinder Pressure Gauge 0-3000 psi
Working Pressure Gauge 0-150 psi
Oxygen Cylinder Inlet Fitting
Oxygen Regulator Adjusting Screw
Oxygen Hose Outlet Fitting

Oxygen Regulator

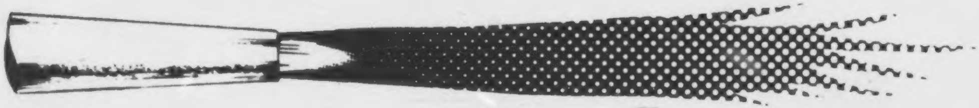

Cylinder Pressure Gauge 0-400 psi
Working Pressure Gauge 0-30 psi
Acetylene Cylinder Inlet Fitting
Acetylene Regulator Adjusting Screw
Acetylene Hose Outlet Fitting

Acetylene Regulator

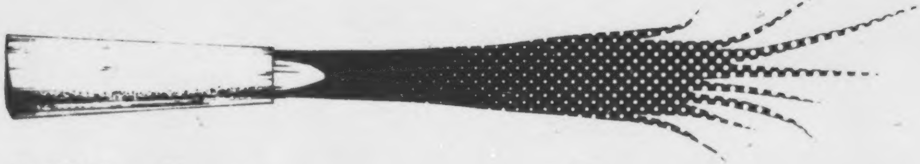
Oxyacetylene Fusion Welding Flames



Carburizing Flame



Neutral Flame



Oxidizing Flame

AM I - 269-A

OXYACETYLENE FUSION WELDING
UNIT VI

JOB SHEET #1--TURN ON, LIGHT, ADJUST, AND TURN OFF OXYACETYLENE WELDING EQUIPMENT

I. Tools and equipment

- A. Oxygen cylinder
- B. Acetylene cylinder
- C. Hoses
- D. Oxygen and acetylene regulators
- E. Torch body and welding tips
- F. Cylinder holder and hose rack
- G. Flint lighter
- H. Welding goggles with #5 lens
- I. Gloves

II. Procedure

A. To turn on and light torch

1. Check all cylinder, regulator, and torch valves to make sure they are turned off
2. Open acetylene cylinder valve 1/2 to 3/4 of a turn

   (CAUTION: Never open valve more than 1 1/2 turns.)
3. Open acetylene valve on torch one turn to purge line

   (CAUTION: Acetylene pressure should never exceed 15 psi.)
4. Turn acetylene regulator pressure adjusting screw clockwise until desired working pressure is reached

   (NOTE: The working pressure is determined by the size of the tip.)
5. Close acetylene valve on torch
6. Open oxygen cylinder valve all the way and tighten in open position
7. Open oxygen torch valve one turn

JOB SHEET #1

8. Turn oxygen regulator pressure adjusting screw clockwise until desired pressure is reached

   (NOTE: The working pressure is determined by the size of the tip.)

9. Close oxygen valve on torch

10. Open acetylene valve on torch 1/4 turn

11. Light the torch with flint lighter and adjust until smoke on flame clears

12. Open oxygen torch valve and adjust to a neutral flame with a tiny trace of feather on the inner cone

B. To adjust welding torch for the three types of flames--Start with a neutral flame

   1. To produce a carburizing flame--Reduce the supply of oxygen by slowly closing the oxygen torch valve until an excess acetylene feather is produced

   2. To produce an oxidizing flame--Increase the supply of oxygen by slowly opening the oxygen torch valve until a short, white inner cone is produced

C. To turn off the torch and oxyacetylene welding unit

   1. Close acetylene torch valve

   2. Close oxygen torch valve

   3. Close acetylene cylinder valve

   4. Close oxygen cylinder valve

   5. Open acetylene torch valve

      (NOTE: When gauges reach 0, release acetylene regulator pressure adjusting screw and close torch valve.)

   6. Open oxygen valve on torch

      (NOTE: When gauges reach 0, release oxygen regulator pressure adjusting screw and close torch valve.)

      (CAUTION: Do not open the acetylene and oxygen torch valves at the same time.)

   7. Place torch and hoses on hanger or brackets

OXYACETYLENE FUSION WELDING
UNIT VI

JOB SHEET #2--CONSTRUCT A CORNER WELD WITHOUT A FILLER ROD

I. Tools and materials

  A. Oxyacetylene welding unit

  B. Welding tip (according to manufacturer's recommendations)

  C. Gloves

  D. Goggles

  E. Pliers

  F. Wire brush

  G. Flint lighter

  H. Firebrick

  I. Mild steel, 2 strips of 16 gauge, 1 1/4" x 6"

II. Procedure

  A. Prepare metal for welding

  B. Place metal in welding position

  C. Turn on oxyacetylene unit

  D. Set working pressure

  (NOTE: Refer to manufacturer's recommendations.)

  E. Light torch and adjust to a neutral flame with very slight feather

  F. Tack weld metal in position

  G. Place inner cone about 1/16" to 1/8" from plate

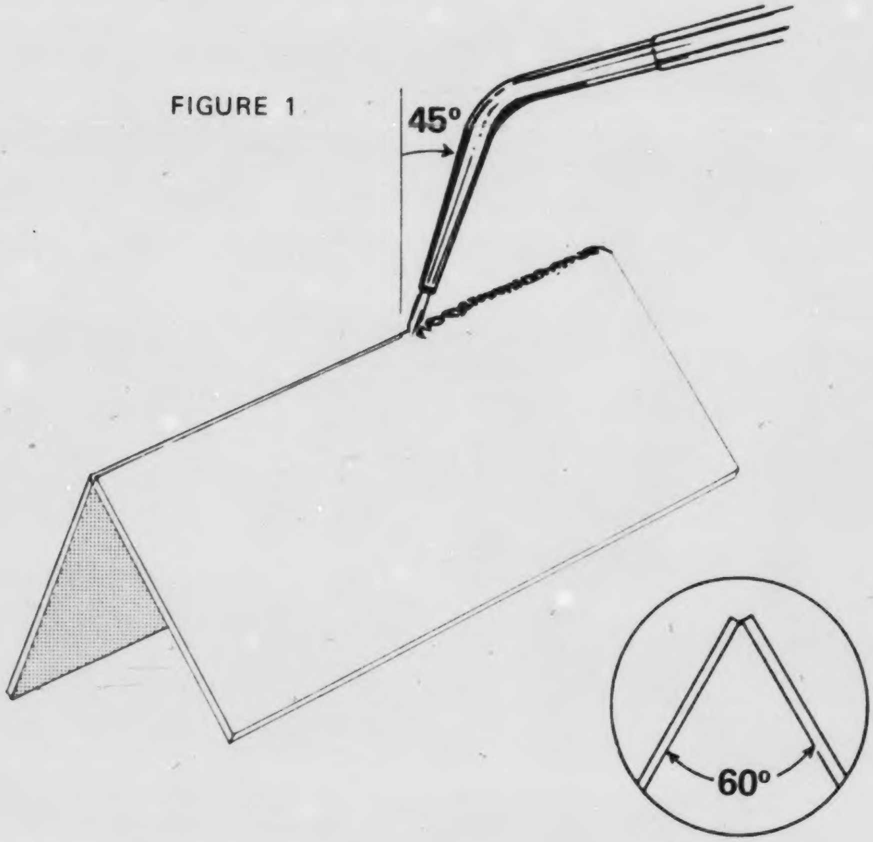
  (NOTE: Do not begin travel until you have established a molten puddle.)

  H. Begin welding at right end

JOB SHEET #2

I. Hold tip vertically at 45° angle from direction of travel (Figure 1)

FIGURE 1



J. Move flame slowly down the joint, forming a puddle as you travel from right to left

K. Examine welded joint for good bead characteristics and penetration

L. Show welded joint to instructor

OXYACETYLENE FUSION WELDING
UNIT VI

JOB SHEET #3--LAY BEADS ON GAUGE METAL WITHOUT FILLER ROD

I. Tools and materials

   A. Oxyacetylene welding unit

   B. Welding tip (according to manufacturer's recommendations)

   C. Gloves

   D. Goggles

   E. Pliers

   F. Wire brush

   G. Flint lighter

   H. Firebrick

   I. Mild steel, 1 strip of 16 gauge, 1 1/4" x 6"

II. Procedure

   A. Prepare metal for welding

   B. Place metal in welding position

   C. Turn on oxyacetylene unit

   D. Set working pressure

   (NOTE: Refer to manufacturer's recommendations.)

   E. Light torch and adjust to a neutral flame

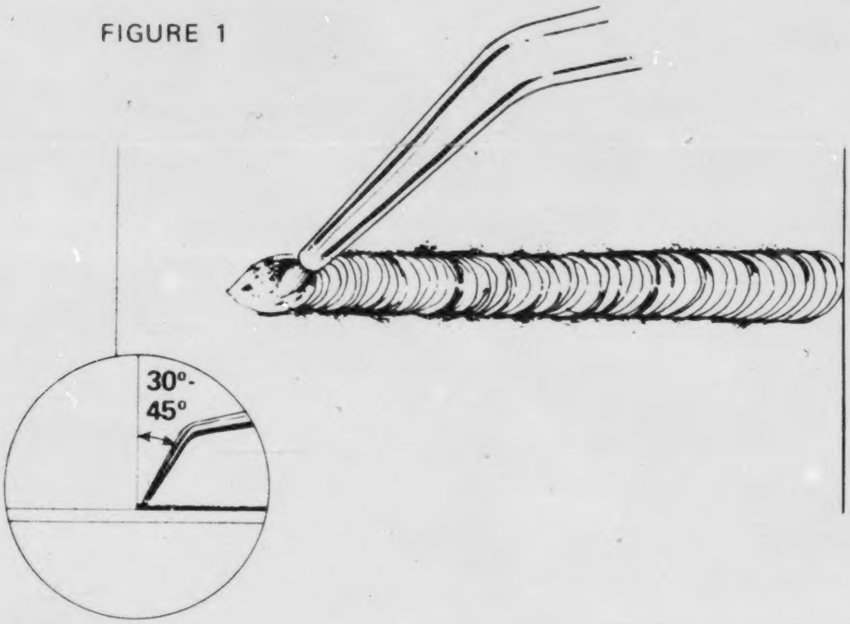
   F. Place inner cone about 1/16" to 1/8" from metal

   (NOTE: Do not begin travel until you have established a molten puddle.)

JOB SHEET #3

G. Hold torch 30° to 45° from center in direction of travel (Figure 1)

FIGURE 1



H. Move the torch forward slowly, allowing the metal to melt

I. Show beads to instructor

OXYACETYLENE FUSION WELDING
UNIT VI

JOB SHEET #4--LAY BEADS ON GAUGE METAL WITH FILLER ROD

I. Tools and materials

   A. Oxyacetylene welding unit

   B. Welding tip (according to manufacturer's recommendations)

   C. Gloves

   D. Goggles

   E. Pliers

   F. Wire brush

   G. Flint lighter

   H. Firebrick

   I. Mild steel, 1 strip of 16 gauge, 1 1/4" x 6"

   J. Mild steel filler rod (according to manufacturer's recommendations)

II. Procedure

   A. Prepare metal for welding

   B. Place metal in welding position

   C. Turn on oxyacetylene unit

   D. Set working pressure

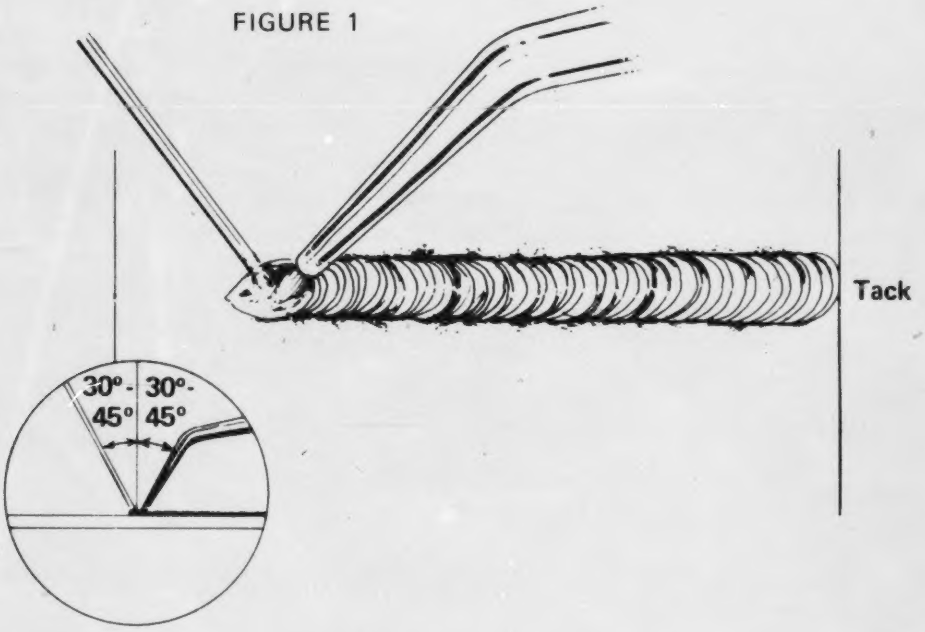
   (NOTE: Refer to manufacturer's recommendations.)

   E. Light torch and adjust to a neutral flame

JOB SHEET #4

F. Hold torch 30° to 45° from center (Figure 1)

FIGURE 1



G. Place inner cone about 1/16" to 1/8" from surface of puddle

(NOTE: Do not begin travel until you have established a molten puddle.)

H. Add filler rod to front edge of puddle in front of torch

I. Move puddle forward with torch and allow puddle to form in base metal

J. Add rod to front edge of puddle and withdraw rod as you move puddle forward

K. Keep puddle the same size and shape for the entire length of the bead

L. Show bead to instructor when completed

OXYACETYLENE FUSION WELDING
UNIT VI

JOB SHEET #5--WELD BUTT JOINTS WITH FILLER ROD

I. Tools and materials

   A. Oxyacetylene welding unit

   B. Welding tip (according to manufacturer's recommendations)

   C. Gloves

   D. Goggles

   E. Pliers

   F. Wire brush

   G. Flint lighter

   H. Firebrick

   I. Mild steel, 2 strips of 16 gauge, 1 1/4" x 6"

   J. Mild steel filler rod (according to manufacturer's recommendations)

II. Procedure

   A. Prepare metal for welding

   B. Place metal in welding position

   C. Turn on oxyacetylene unit

   D. Set working pressure

   (NOTE: Refer to manufacturer's recommendations.)

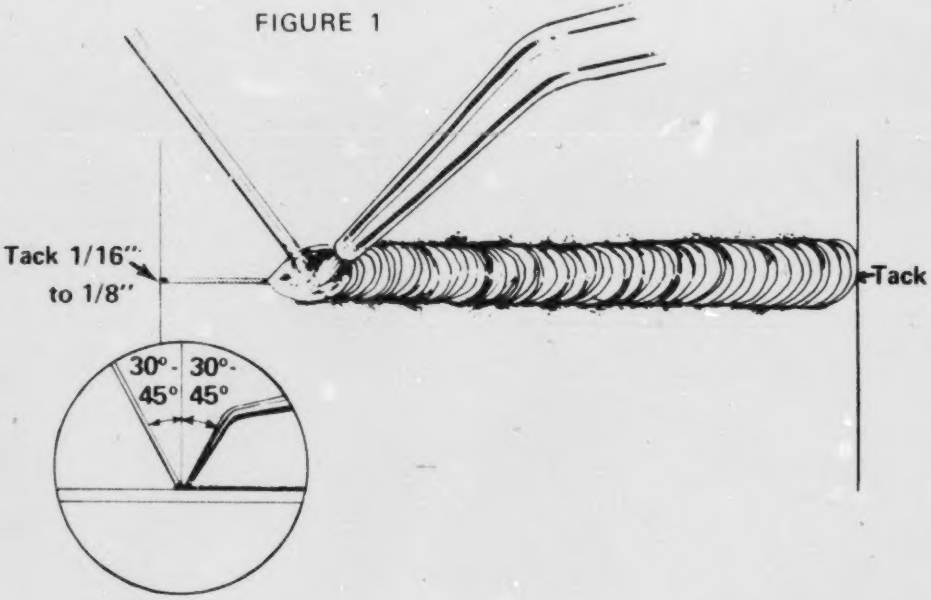
   E. Light torch and adjust to a neutral flame

   F. Tack weld metal together at both ends of joint

JOB SHEET #5

G. Hold torch 30° to 45° from center (Figure 1)

FIGURE 1



(NOTE: Do not begin travel until you have established a molten puddle.)

H. Place inner cone about 1/16" to 1/8" from surface of puddle

I. Add filler rod to front edge of puddle in front of torch

J. Move puddle forward with torch and allow puddle to form in base metal

K. Add rod to front edge of puddle and withdraw rod as you move puddle forward

L. Keep puddle the same size and shape for the entire length of the bead

M. Show bead to instructor

OXYACETYLENE FUSION WELDING
UNIT VI

TEST

1. Match the terms on the right to the correct definitions.

_____a. Metal to be welded

_____b. Fire inside the torch; indicated by a hissing or squealing sound

_____c. Joining of pieces of metal by heating the adjoining edges to the fusion or melting point and allowing them to flow or run together and then cool

_____d. Inner white part of a neutral flame

_____e. Distance from the original surface of the base metal to that point at which fusion ceases

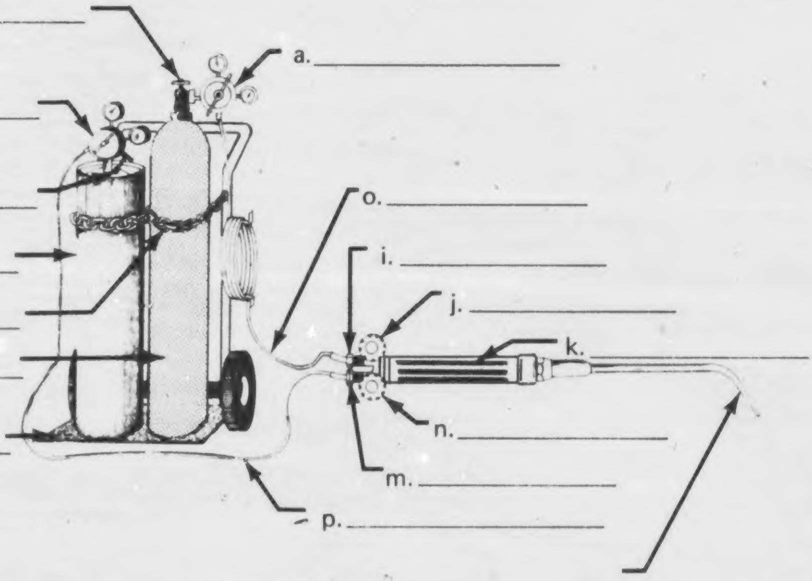
_____f. Short weld used for temporarily holding metal in place

_____g. Mixture with metallic properties; composed of two or more elements of which at least one is a metal

_____h. Momentary burning back of the flame into the tip; flame goes out with a loud snap or pop

1. Tack weld
2. Flashback
3. Backfire
4. Inner cone
5. Alloy
6. Base metal
7. Penetration
8. Fusion welding

2. Identify the parts of the oxyacetylene fusion welding equipment illustrated below by writing the correct names in the blanks.



a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

h. ____________________

i. ____________________

j. ____________________

k. ____________________

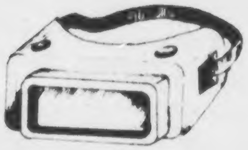
l. ____________________

m. ____________________

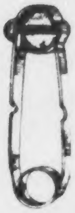
n. ____________________

o. ____________________

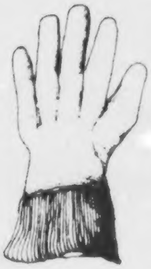
p. ____________________



q. ____________________



r. ____________________



s. ____________________

3. Select from the list below factors that determine weld quality by placing an "X" in the blank.

   _____a. Proper flame adjustment

   _____b. Angle of tip

   _____c. Distance from work

   _____d. Thickness of metal

   _____e. Speed of travel

   _____f. Movement of tip

   _____g. Width of bead

4. List three properties of a good weld.

   a.

   b.

   c.

5. Select from the list below factors that determine tip size by placing an "X" in the blank.

   _____a. Size of welding rod

   _____b. Temperature of metal

   _____c. Thickness of metal

   _____d. Distance to work

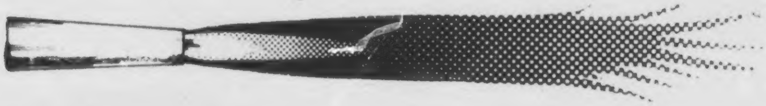
6. List two factors that determine the type of filler rod to use in oxyacetylene welding.

   a.

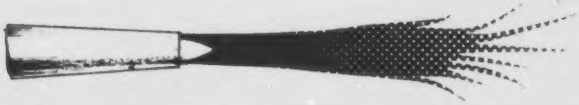
   b.

7. State in writing the purpose of a filler rod.

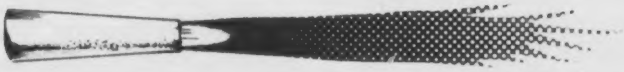
8. Identify the three types of flames illustrated below by writing the correct names in the blanks.



a. ______________________



b. ______________________



c. ______________________

9. Demonstrate the ability to:

a. Turn on, light, adjust, and turn off the oxyacetylene welding equipment.

b. Construct a corner weld without filler rod.

c. Lay beads on gauge metal without filler rod.

d. Lay beads on gauge metal with filler rod.

e. Weld butt joints with filler rod.

(NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

OXYACETYLENE FUSION WELDING
UNIT VI

ANSWERS TO TEST

1. a. 6
   b. 2
   c. 8
   d. 4
   e. 7
   f. 1
   g. 5
   h. 3

2. a. Oxygen regulator
   b. Oxygen cylinder valve
   c. Acetylene regulator
   d. Acetylene cylinder valve
   e. Acetylene cylinder
   f. Safety chain
   g. Oxygen cylinder
   h. Cylinder truck
   i. Oxygen fitting
   j. Oxygen torch valve
   k. Torch body
   l. Welding tip
   m. Acetylene fitting
   n. Acetylene torch valve
   o. Oxygen hose
   p. Acetylene hose
   q. Welding goggles
   r. Flint lighter
   s. Welding gloves

3. a, b, c, e, f

4. Any three of the following:
    a. Consistent width
    b. Straightness
    c. Slightly crowned
    d. Fused into base metal
    e. Clean appearance
5. a, c
6. a. Rod with similar properties as base metal
    b. Thickness of metal
7. To add strength to weld or joint
8. a. Carburizing
    b. Oxidizing
    c. Neutral
9. Performance skills evaluated to the satisfaction of the instructor

OXYACETYLENE BRAZE WELDING
UNIT VII

UNIT OBJECTIVE

After completion of this unit, the student should be able to describe the differences between braze welding and fusion welding and list advantages and disadvantages of braze welding. The student should be able to describe the reaction when adding bronze to base metal that is too hot, too cold, or of correct temperature. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with brazing to the correct definitions.
2. List advantages and disadvantages of braze welding.
3. State in writing the importance of having a chemically clean metal surface in braze welding.
4. Select from a list methods for removing oxides from a clean metal surface.
5. Describe the differences between braze welding and fusion welding.
6. List purposes for using flux.
7. Describe the reaction of molten bronze when the temperature of the base metal is too hot, too cool, and correct.
8. Demonstrate the ability to braze weld a square groove butt joint.

OXYACETYLENE BRAZE WELDING
UNIT VII

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparency.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Demonstrate and discuss procedure outlined in the job sheet.

  (NOTE: The instructor may want to secure the film on braze welding from a local welding supplier or from the Curriculum and Instructional Materials Center to show to the class.)

  G. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Demonstrate the ability to accomplish the procedure outlined in the job sheet.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency master: TM 1--Braze Welding a Butt Joint

  D. Job Sheet #1--Braze Weld a Square Groove Butt Joint

E. Test

F. Answers to test

II. References:

A. *The Oxyacetylene Handbook: A Manual on Oxyacetylene Welding and Cutting Procedures.* New York: Union Carbide Corp./Linde Div., 1960.

B. Althouse, Andrew D.; Turnquist, Carl H.; and Bowditch, William A. *Modern Welding.* Homewood, Illinois: Goodheart-Willcox Co., Inc., 1965.

C. Giachino, J. W.; Weeks, William; and Brune, Elmer. *Welding Skills and Practices.* Chicago: American Technical Society, 1967.

III. Film--"Oxyacetylene Welding: Torch Techniques." Film Library, Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1515 West Sixth Street, Stillwater, Oklahoma 74074.

OXYACETYLENE BRAZE WELDING
UNIT VII

INFORMATION SHEET

I. Terms and definitions

A. Braze welding--Heating the base metal to a dull red color and depositing a head over the seam (joint) with a bronze filler rod; the base metal is not melted (Transparency 1)

B. Malleability--Property of metals which allows them to be bent or permanently distorted without rupture; opposite of brittleness

C. Ductile--Capable of being drawn or stretched out

D. Tinning operation--Melting a small amount of bronze rod onto the surface and allowing it to spread along the entire seam (joint)

(NOTE: It is this flow of the thin film of bronze which is known as *tinning.*)

E. Flux--Chemical used to clean metals and to promote fusion during the welding process

II. Advantages and disadvantages of braze welding

A. Advantages

1. Provides less chance of destroying main characteristics of base metal since it is not heated to a molten condition
2. Consumes less gas
3. Can be used on thin metals
4. Used on malleable castings
5. Increases speed of joining metals
6. May be used to join different kinds of metals

B. Disadvantages

1. Cannot be used on metal where stress is a factor
2. Is expensive to use

INFORMATION SHEET

3. Is not recommended for parts which are raised to temperatures higher than the melting point of bronze, either in service or during heat treatment

(NOTE: Bronze will lose its strength at temperatures above 500°F or 260°C.)

4. Will not bond unless base metal has corrosion-resistant properties similar to bronze

III. Importance of a chemically clean surface in braze welding

A. Ensure that the molten bronze will stick to the base metal

B. Have a stronger bond on base metal

C. Allow bronze to flow smoothly and evenly over entire weld area

IV. Methods for removing oxides from clean metal surface

A. Mechanical means

1. Wire brush

2. Grinder

B. Chemical means--Flux

(NOTE: Both methods should be used to completely remove the oxides.)

V. Differences between braze welding and fusion welding

A. Braze welding

1. Base metal is not melted

(NOTE: The base metal is heated only to a dull red color.)

2. An alloy rod is used to lay a thin coat of bronze along the seam

B. Fusion welding

1. Base metal is melted and joined

2. Rod with similar characteristics of base metal must be used

INFORMATION SHEET

VI. Purposes for using flux

   A. Clean the base metal chemically

   B. Prevent oxidation of filler metal

   C. Float and remove oxides already present

   D. Increase flow of filler metal

   E. Increase ability of filler metal to adhere to the base metal

   F. Bring the filler metal into immediate contact with metals being joined

   G. Permit the filler metal to penetrate the pores of the base metal

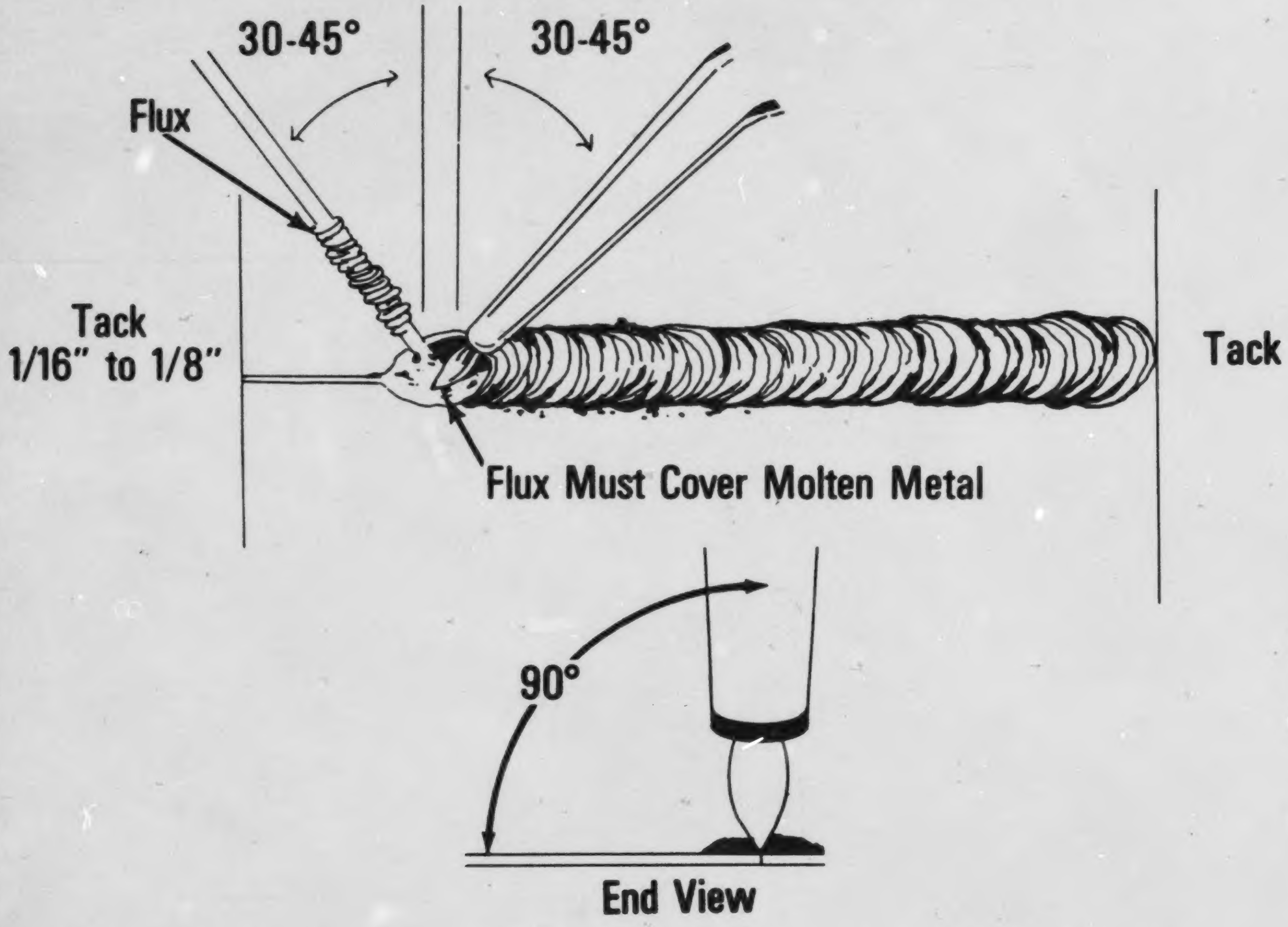
VII. Reaction of molten bronze at different temperatures

   A. Too hot--The molten bronze will tend to boil and form little balls

   B. Too cool--The molten bronze will form into drops rather than flowing evenly over the surface

   C. Correct--The molten bronze will spread evenly and flow over a considerable area

Braze Welding A Butt Joint



30-45°
30-45°
Flux
Tack
1/16" to 1/8"
Tack
Flux Must Cover Molten Metal
90°
End View

OXYACETYLENE BRAZE WELDING
UNIT VII

JOB SHEET #1--BRAZE WELD A SQUARE GROOVE BUTT JOINT

I. Tools and materials

A. Oxyacetylene welding unit

B. Gloves

C. Safety glasses

D. Goggles

E. Welding tip (according to manufacturer's recommendations)

F. Wire brush

G. Flint lighter

H. Firebrick

I. Mild steel 1/8" thick, 1 1/4" x 6" (2 strips)

J. Bronze filler rod (according to manufacturer's recommendations)

K. Welding flux

II. Procedure

A. Clean metal

B. Place metal in brazing position, 1/16" to 1/8" apart

C. Turn on oxyacetylene unit

D. Adjust proper working pressure of oxygen and acetylene

(NOTE: Use manufacturer's recommendations.)

E. Place metal on firebrick

(NOTE: Do not lay metal flat on brick. Arrange metal so a small space will be between the base metal and the firebrick.)

F. Light and adjust torch to a neutral or slightly oxidizing flame

JOB SHEET #1

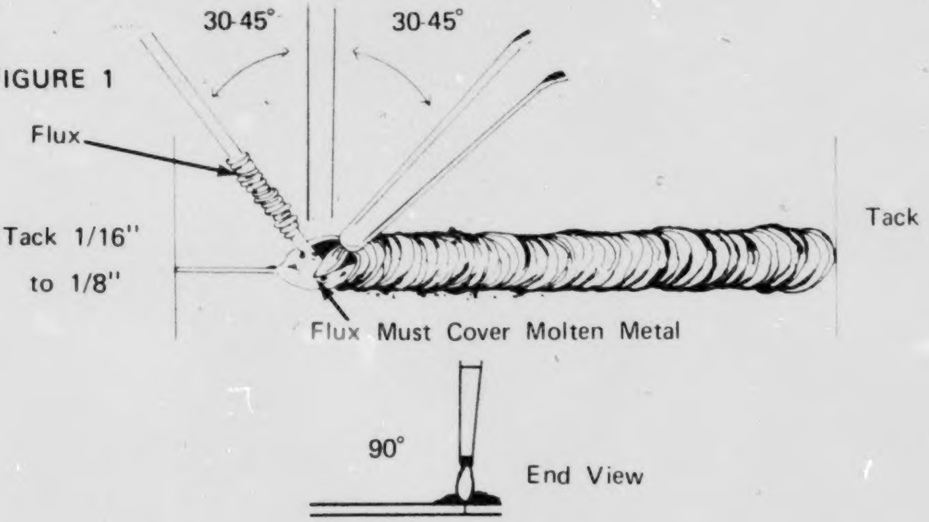
G. Preheat the end of the brazing rod and dip in the flux or use fluxed rod

H. Tack metal in place using braze filler metal

I. Heat the surface of the weld area slightly

J. Hold torch 30° to 45° vertically; hold filler rod at same angle in opposite direction (Figure 1)

FIGURE 1



K. Melt a small amount of bronze rod onto the surface and allow it to spread along the entire seam when a cherry red color occurs

L. Start depositing the proper size bead when the base metal is tinned sufficiently

(NOTE: When metal is not hot enough, the bronze will form into drops; when metal is too hot, bronze tends to boil.)

M. Complete the weld

N. Have instructor inspect weld

O. Practice doing other welds

OXYACETYLENE BRAZE WELDING
UNIT VII

TEST

1. Match terms on the right to the correct definitions.

_____a. Capable of being drawn or stretched out

_____b. Chemical used to clean metals and to promote fusion during the welding process

_____c. Property of metals which allows them to be bent or permanently distorted without rupture; opposite of brittleness

_____d. Heating the base metal to a dull red color and depositing a head over the seam (joint) with a bronze filler rod; the base metal is not melted

_____e. Melting a small amount of bronze rod onto the surface and allowing it to spread along the entire seam (joint)

1. Flux
2. Braze welding
3. Malleability
4. Tinning operation
5. Ductile

2. List three advantages and three disadvantages of braze welding.

a. Advantages

1)

2)

3)

b. Disadvantages

1)

2)

3)

3. State in writing the importance of having a chemically clean metal surface in braze welding.

4. Select from the list below methods for removing oxides from a clean metal surface by placing an "X" in the blanks.

______a. Wire brush

______b. Hammer

______c. Acid

______d. Grinder

______e. Flux

______f. Water

5. Describe the differences between braze welding and fusion welding.

6. List five purposes for using flux.

   a.

   b.

   c.

   d.

   e.

7. Describe the reactions of molten bronze when the temperature of the base metal is:

   a. Too hot

   b. Too cool

   c. Correct

8. Demonstrate the ability to braze weld a square groove butt joint.

   (NOTE: If this has not been accomplished prior to the test, ask the instructor when the above activity should be completed.)

OXYACETYLENE BRAZE WELDING
UNIT VII

ANSWERS TO TEST

1. a. 5
   b. 1
   c. 3
   d. 2
   e. 4

2. Any three from each group:
   a. Advantages
      1) Provides less chance of destroying main characteristics of base metal since it is not heated to a molten condition
      2) Consumes less gas
      3) Can be used on thin metals
      4) Used on malleable castings
      5) Increases speed of joining metals
      6) May be used to join different kinds of metals
   b. Disadvantages
      1) Cannot be used on metal where stress is a factor
      2) Is expensive to use
      3) Is not recommended for parts which are raised to temperatures higher than the melting point of bronze, either in service or during heat treatment
      4) Will not bond unless base metal has corrosion-resistant properties similar to bronze

3. a. Ensure that the molten bronze will stick to the base metal
   b. Have a stronger bond on base metal
   c. Allow bronze to flow smoothly and evenly over entire weld area

4. a, d, e

5. Description should include:

    a. Braze welding

        1) Base metal is not melted

        2) An alloy rod is used to lay a thin coat of bronze along the seam

    b. Fusion welding

        1) Base metal is melted and joined

        2) Rod with similar characteristics of base metal must be used

6. Any five of the following:

    a. Clean the base metal chemically

    b. Prevent oxidation of filler metal

    c. Float and remove oxides already present

    d. Increase flow of filler metal

    e. Increase ability of filler metal to adhere to the base metal

    f. Bring the filler metal into immediate contact with metals being joined

    g. Permit the filler metal to penetrate the pores of the base metal

7. Description should include:

    a. Too hot--The molten bronze will tend to boil and form little balls

    b. Too cool--The molten bronze will form into drops rather than flowing evenly over the surface

    c. Correct--The molten bronze will spread evenly and flow over a considerable area

8. Performance skills evaluated to the satisfaction of the instructor

[redacted]

RULES
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify common types of rules, write the uses of rules with accessories, list general procedures for using rules, and list the common units of measure found on rules. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to linear measurement to the correct definitions.
2. Name basic units of measurement found on rules.
3. List fractional units of measure found on rules.
4. List decimal units found on rules.
5. List metric units found on rules.
6. Identify types of rules used in shop work.
7. Write the uses of rules with accessories.
8. List procedures for using rules.
9. List steps for reading the rule.

RULES
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and assignment sheets.
- C. Provide student with appropriate rules.
- D. Make transparencies.
- E. Discuss unit and specific objectives.
- F. Discuss information and assignment sheets.
- G. Show film.
- H. Prepare and use supplemental materials if available.
- I. Evaluate assignment sheets.
- J. Give test.

II. Student:

- A. Read the objective sheet.
- B. Study the information sheet.
- C. Complete the assignment sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
  1. TM 1--Terms of Linear Measurement
  2. TM 2--Units of Measurement

        3. TM 3--Eighths Rule
        4. TM 4--Sixteenths Rule
        5. TM 5--Thirty-seconds Rule
        6. TM 6--Sixty-fourths Rule
        7. TM 7--Types of Rules
        8. TM 8--Uses of Rules
        9. TM 9--Uses of Rules (Continued)
        10. TM 10--Uses of Rules (Continued)
        11. TM 11--Uses of Rules (Continued)

    D. Assignment sheets
        1. Assignment Sheet #1--Draw Lines
        2. Assignment Sheet #2--Measure Lines
        3. Assignment Sheet #3--Apply Line Measurement
        4. Assignment Sheet #4--Apply Circular Measurement
    E. Answers to assignment sheets
    F. Test
    G. Answers to test

II. References:

A. Busch, Ted. *Fundamentals of Dimensional Metrology.* Albany 5, New York: Wilkie Brothers Foundation, Delmar Publishers, Inc., 1964.

B. Ludwig, Oswald, and McCarthy, Willard. *Metalwork Technology and Practice.* Bloomington, Illinois: McKnight and McKnight Publishing Co., 1969.

C. Walker, John. *Machining Fundamentals.* Homewood, Illinois: Goodheart-Willcox Co., Inc., 1969.

D. Porter, Harold; Lascoe, O. D.; and Nelson, Clyde. *Machine Shop Operations and Setups.* 3rd ed. Chicago: American Technical Society, 1967.

E. Feirer, John Louis, and Tetro, Earl E. *Machine Tool Metalworking: Principles and Practice.* New York: McGraw-Hill Book Co., Inc., 1961.

III. Additional materials:

A. Film--"Precision Measuring: Steel Scale - Part 1, The Fractional Scale." BFA Educational Media, 2211 Michigan Avenue, Santa Monica, California 90404.

B. Filmstrip--"Layout Tools and Measuring Instruments." Film no. 8, Series no. 1998. The Jam Handy Organization, 2821 East Grand Boulevard, Detroit, Michigan 48211.

(NOTE: The following film is available to Oklahoma instructors from the Curriculum and Instructional Materials Center, State Department of Vocational and Technical Education, 1515 West Sixth Avenue, Stillwater, Oklahoma 74074.)

C. Film--"Metric System." Films Incorporated, 1144 Wilmette Avenue, Wilmette, Illinois 60091.

RULES
UNIT I

INFORMATION SHEET

I. Terms and definitions related to linear measurement (Transparency 1)

   A. Steel rule--Semiprecision measuring instrument graduated in fractional or decimal parts of an inch

   B. Graduation--Marking found on rules and scales to denote unit of length

   C. Error--Mistake in the reading or total measurement

   D. Reliable measure--Accurate or true measurement

   E. Reference point--Starting point of measurement for both workpiece and rule

II. Basic units of measurement (Transparency 2)

   A. Fractional

   B. Decimal

   C. Metric

III. Fractional units found on rules (Transparencies 3, 4, 5, and 6)

   A. Eighths (1/8")

   B. Sixteenths (1/16")

   C. Thirty-seconds (1/32")

   D. Sixty-fourths (1/64")

IV. Decimal units found on rules (Transparency 2)

   A. Tenths (0.1)

   B. Hundredths (0.01)

V. Metric units found on rules (Transparency 2)

   A. Meter (1.0 m)

   B. Decimeter (0.1 m)

7

INFORMATION SHEET

C. Centimeter (0.01 m)

D. Millimeter (0.001 m)

VI. Rules used in shop work (Transparency 7)

A. Steel rule

B. Narrow flexible rule

C. Hook rule

D. Short rule with holder

E. Slide caliper rule

VII. Uses of the rule with accessories

A. Depth gauge--Measure depths of grooves, recesses, and shoulders (Transparency 8)

B. Combination square--Lay out and measure lengths from 90° and 45° angles (Transparency 8)

C. Bevel protractor--Lay out and measure lengths of any angle between 0° and 180° (Transparency 9)

D. Center head--Locate center points on round workpiece (Transparency 9)

E. Key seat measurement--Locate parallel axis and width of key seats (Transparency 10)

F. Drill point gauge--Measure length, drill point angle, and lip length of a drill bit (Transparency 10)

G. Measurement transfer--Measure lengths taken from dividers and calipers (Transparency 11)

(NOTE: A caliper is an instrument used in measuring diameters.)

VIII. Procedures for using rules

A. Use the proper length and graduation

B. Use finest graduation for accuracy

C. Use a good quality rule

INFORMATION SHEET

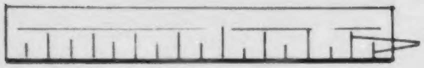
- D. Do not bend or distort a steel rule
- E. Use only for intended purpose
- F. Use whole unit graduation as reference for accuracy
- G. Use rule on edge for better reading
- H. Use rule along axis parallel to plane of measurement

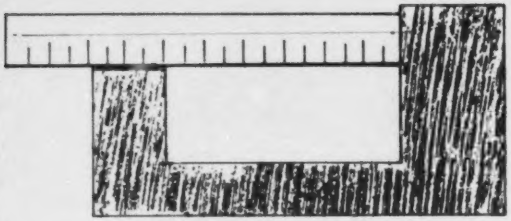
IX. Steps for reading the rule (Assignment Sheets #1, #2, #3, and #4)

- A. Select scale of the required units
- B. Total the number of graduations
- C. Count whole units
- D. Reduce graduations to lowest terms

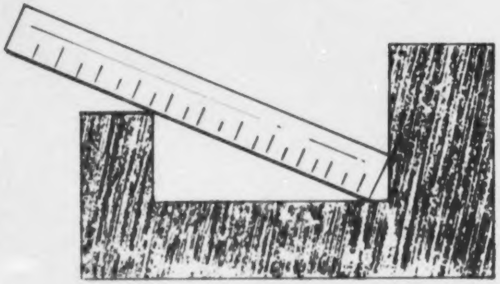
Terms of Linear Measurement

Steel Rule

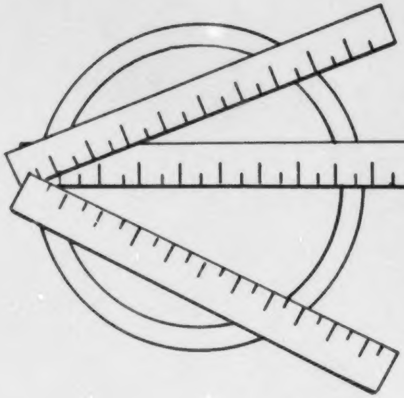

Graduations

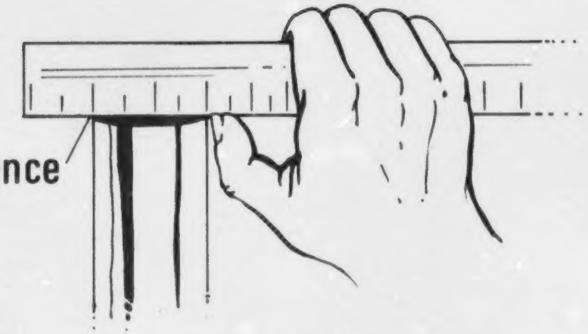


Reliable Measure



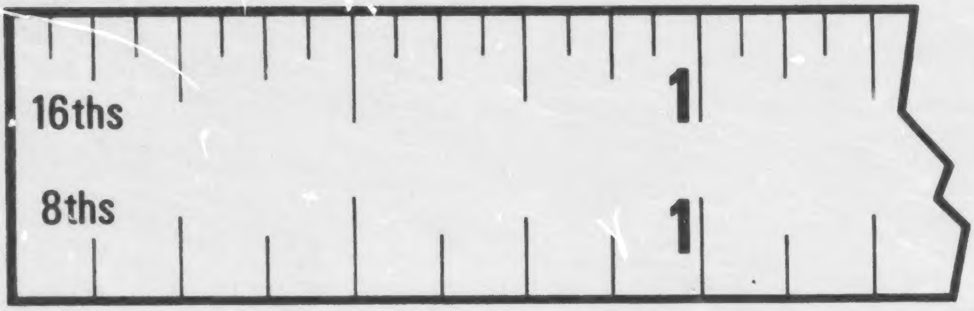
Error


Error
Reliable Measure
Error

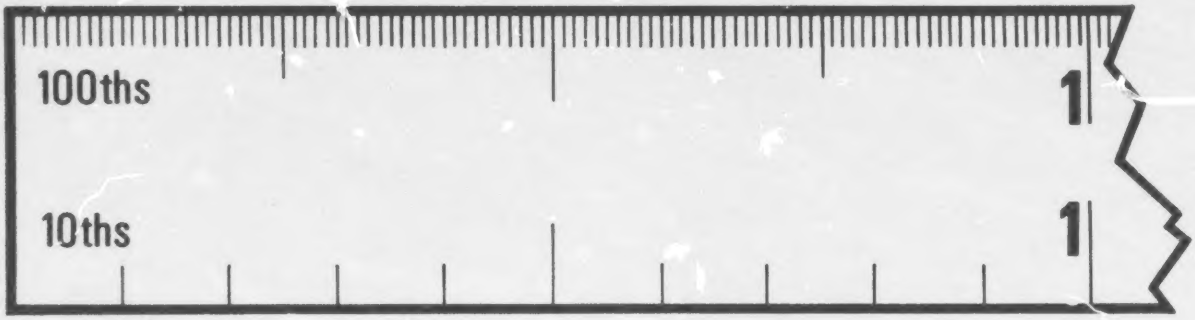

Reference Point

Reliable Measure

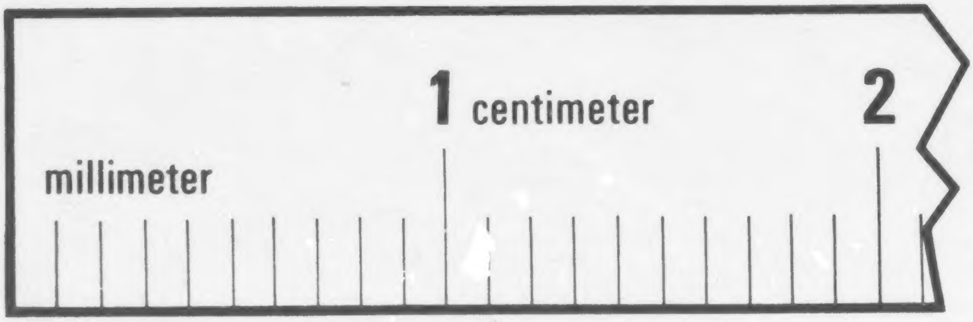
Units of Measurement


16ths
1
8ths
1

Fractional Rule

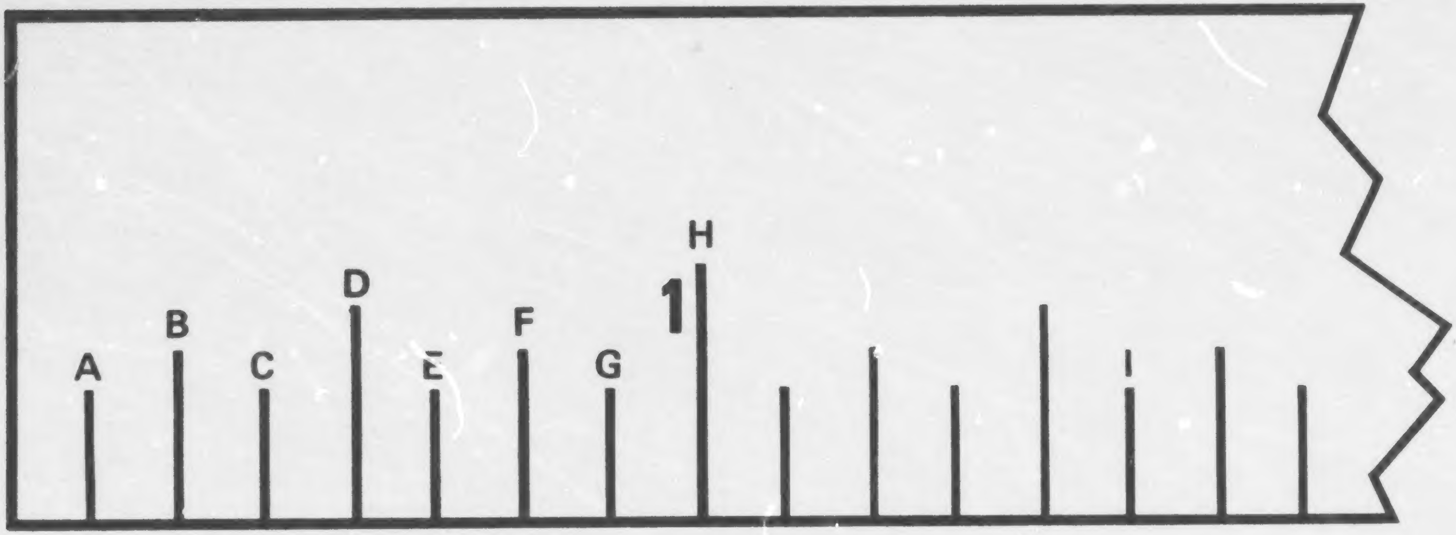

100ths
1
10ths
1

Decimal Rule


1
centimeter
2
millimeter

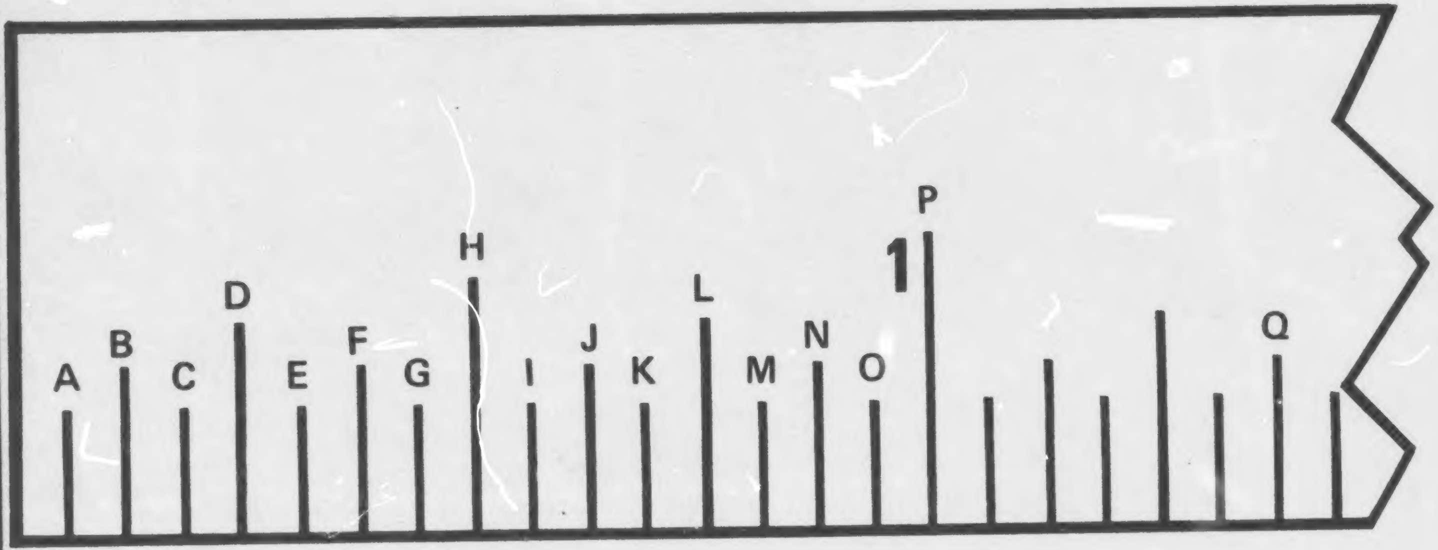
Metric Rule

Eighths Rule


A
B
C
D
E
F
G
H
1
I

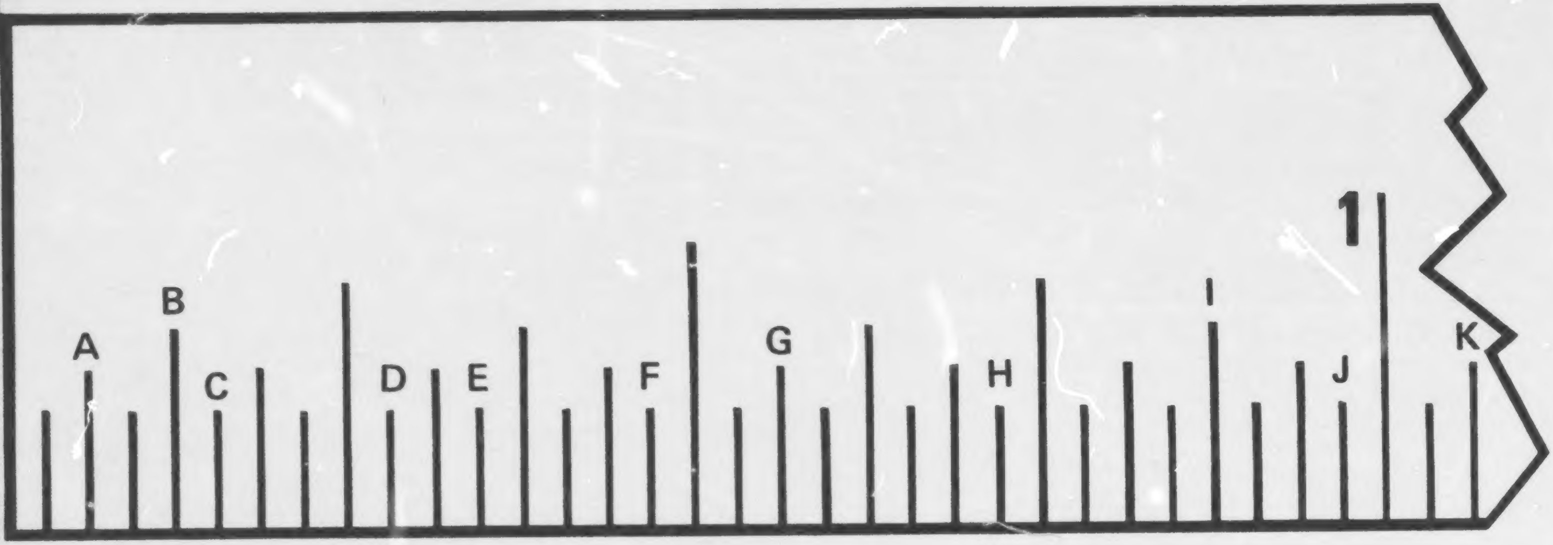
A = 1/8, B = 2/8 = 1/4, C = 3/8, D = 4/8 = 1/2,
E = 5/8, F = 6/8 = 3/4, G = 7/8, H = 8/8 = 1,
I = 13/8 = 1 5/8

Sixteenths Rule


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
1
P
Q

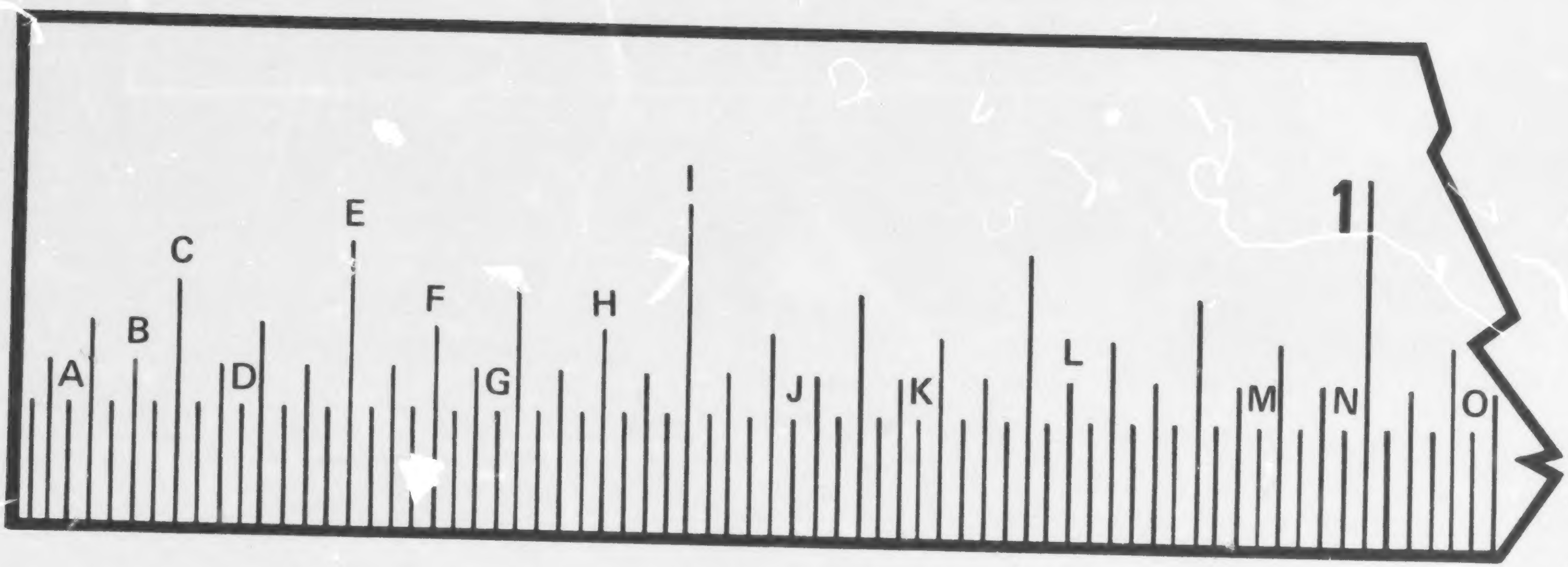
A = 1/16, B = 2/16 = 1/8, C = 3/16, D = 4/16 = 1/4,
E = 5/16, F = 6/16 = 3/8, G = 7/16, H = 8/16 = 1/2,
I = 9/16, J = 10/16 = 5/8, K = 11/16, L = 12/16 = 3/4,
M = 13/16, N = 14/16 = 7/8, O = 15/16, P = 16/16 = 1,
Q = 22/16 = 1 6/16 = 1 3/8

Thirty-Seconds Rule


1
A
B
C
D
E
F
G
H
I
J
K

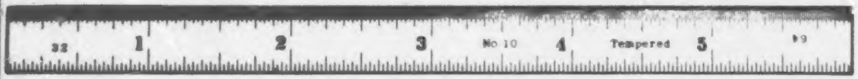
A = 2/32 = 1/16, B = 4/32 = 1/8, C = 5/32, D = 9/32,
E = 11/32, F = 15/32, G = 18/32 = 9/16, H = 23/32,
I = 28/32 = 14/16 = 7/8, J = 31/32,
K = 34/32 = 1 2/32 = 1 1/16

Sixty-Fourths Rule

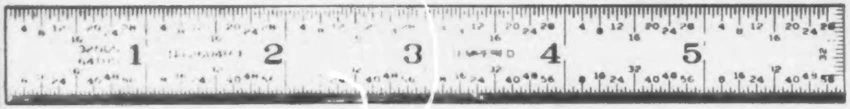

A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
1

A = 3/64, B = 6/64 = 3/32, C = 8/64 = 1/8, D = 11/64,
E = 16/64 = 8/32 = 1/4, F = 20/64 = 10/32 = 5/16,
G = 23/64, H = 28/64 = 14/32 = 7/16, I = 32/64 = 1/2,
J = 37/64, K = 43/64, L = 50/64 = 25/32, M = 59/64,
N = 63/64, O = 69/64 = 1 5/64

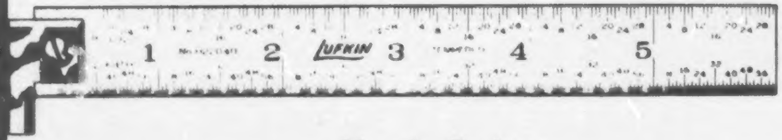
Types of Rules


32
1
2
3
No 10
4
Tempered
5

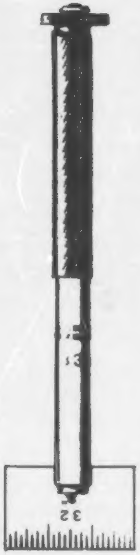
Narrow Flexible Rule



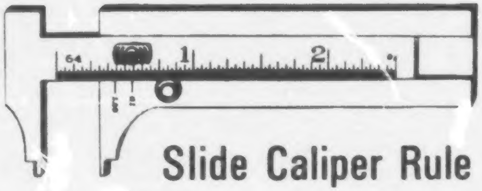
Steel Rule


1
2
LUFKIN
3
4
5

Hook Rule

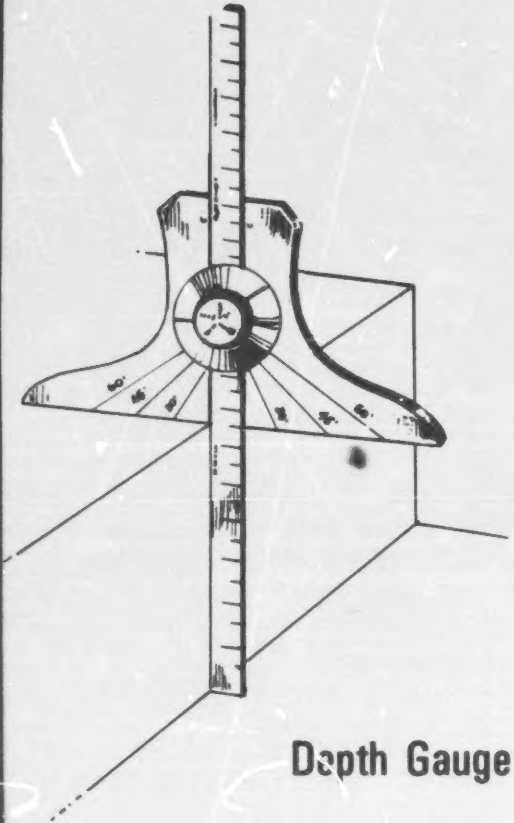


Short Rule with Holder

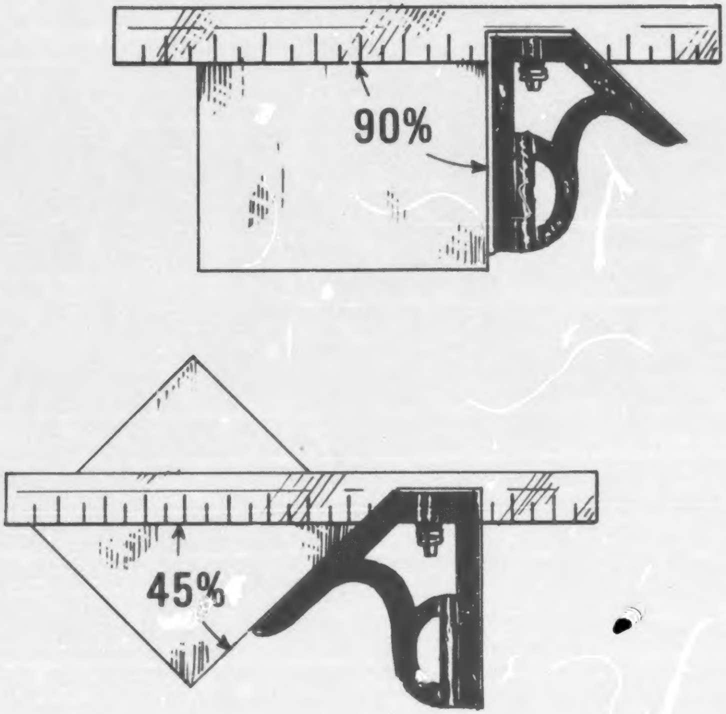


Slide Caliper Rule

Uses of Rules



Depth Gauge

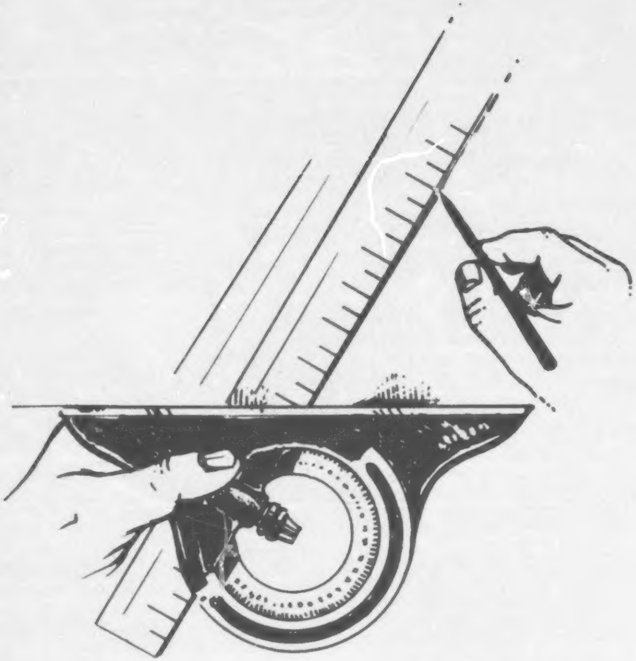


Combination Square

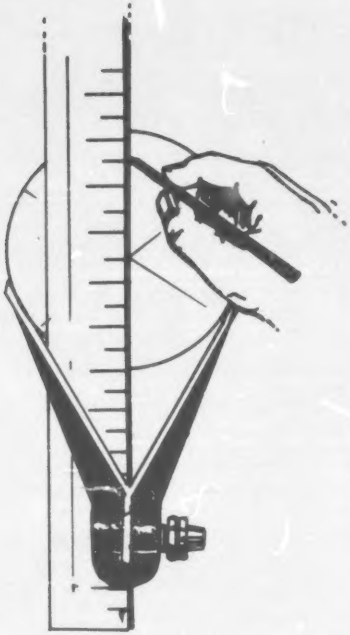
AM I - 25-B

Uses of Rules

(Continued)



Bevel Protractor

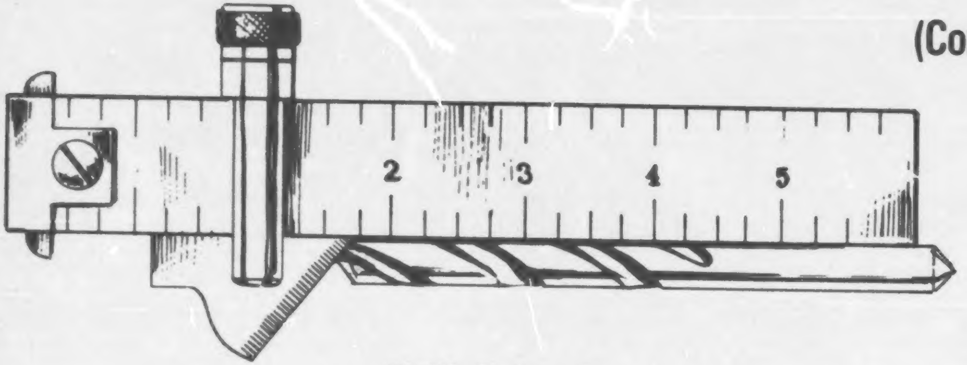


Center Head

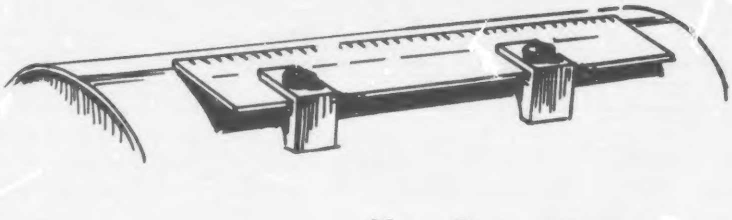
AM I-27-B

Uses of Rules

(Continued)



Drill Point Gauge

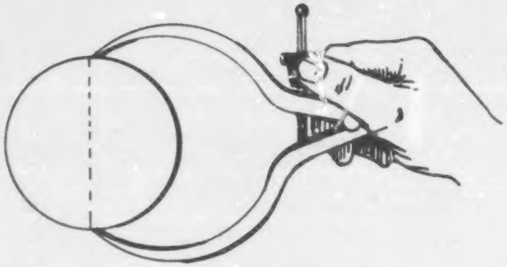


Key Seat Measurement

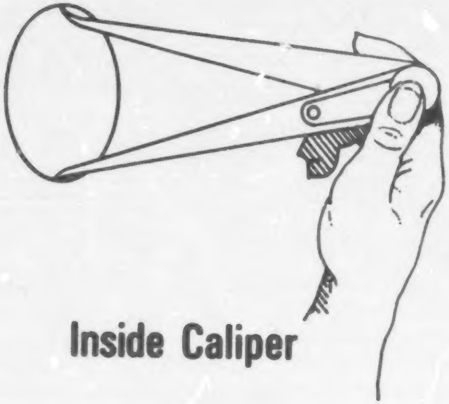
Uses of Rules

(Continued)

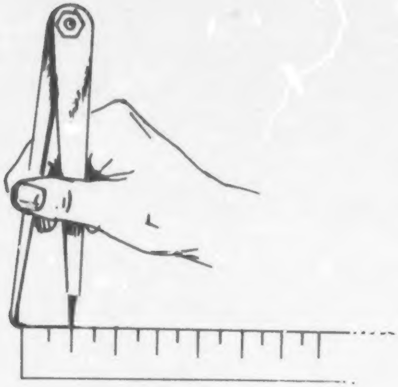
MEASUREMENT TRANSFER



Outside Caliper



Inside Caliper



Hermaphrodite Caliper

RULES
UNIT I

ASSIGNMENT SHEET #1--DRAW LINES

Directions: With the steel scale, draw straight lines of the following lengths.

1. 2 1/4 inches
2. 3 3/4 inches
3. 4 1/2 inches
4. 1 1/8 inches
5. 2 5/8 inches
6. 4 3/8 inches
7. 5 7/8 inches
8. 2 1/16 inches
9. 4 5/16 inches
10. 5 9/16 inches
11. 3 15/16 inches
12. 5 7/32 inches
13. 1 19/32 inches
14. 2 1/64 inches
15. 1 9/64 inches
16. 3 3/64 inches
17. 4 47/64 inches
18. 4 31/32 inches

RULES
UNIT I

ASSIGNMENT SHEET #2--MEASURE LINES

Measure the following lines to the specified graduations. Reduce measures to the lowest terms (i.e., 16/64" = 1/4") and write correct answers on the lines.

1. Measure these lines to the nearest quarter of an inch.

   a. ____________________

   b. ____________________

   c. ____________________

   d. ____________________

2. Measure these lines to the nearest eighth of an inch.

   a. ____________________

   b. ____________________

   c. ____________________

   d. ____________________

3. Measure these lines to the nearest sixteenth of an inch.

   a. ____________________

   b. ____________________

   c. ____________________

   d. ____________________

4. Measure these lines to the nearest thirty-second of an inch.

   a. ____________________

   b. ____________________

   c. ____________________

   d. ____________________

ASSIGNMENT SHEET #2 .

5. Measure these lines to the nearest sixty-fourth of an inch.

   a. ____________________________________

   b. ____

   c. ____

   d. ____________________

6. Measure these lines to the nearest centimeter.

   a. _______________

   b. _______________________________

   c. _____

   d. ____

7. Measure these lines to the nearest millimeter.

   a. ___________

   b. ___________________________

   c. ____

   d. ______

RULES
UNIT I

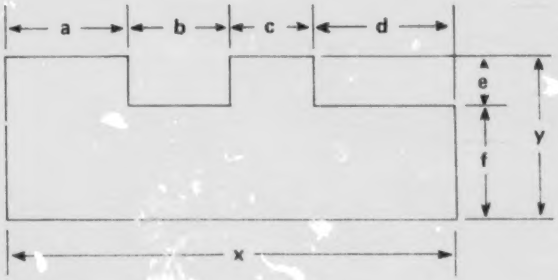
ASSIGNMENT SHEET #3--APPLY LINE MEASUREMENT

Use the rule to measure each lettered dimension on the objects below. Use the finest graduation (64ths) on the rule and reduce measure to lowest terms (i.e., 16/64" = 1/4"). Indicate each individual measurement (in lowest terms) in the correct answer space.

ANSWER

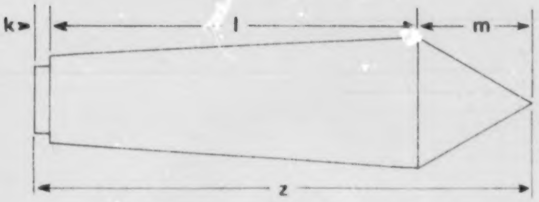
1. a. ____________
b. ____________
c. ____________
d. ____________
e. ____________
f. ____________
x. ____________
y. ____________

1.



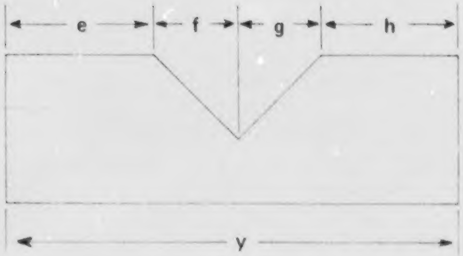
2. k. ____________
l. ____________
m. ____________
z. ____________

2.



3. e. ____________
f. ____________
g. ____________
h. ____________
y. ____________

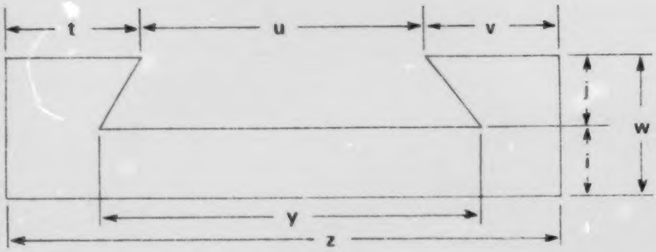
3.



ASSIGNMENT SHEET #3

4.
t. ____________
u. ____________
v. ____________
y. ____________
z. ____________
j. ____________
i. ____________
w. ____________

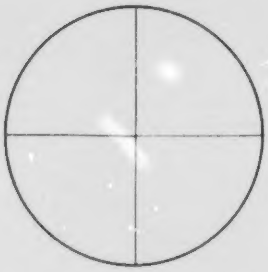
4.



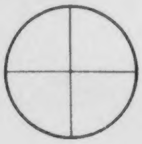
RULES
UNIT I

ASSIGNMENT SHEET #4--APPLY CIRCULAR MEASUREMENT

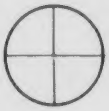
Use the rule to measure each given circle. Use the finest graduation on the rule (64ths) and reduce the dimension to lowest terms (i.e., 16/64" = 1/4"). Make certain that the true diameter of the circle is measured by measuring along the axis line. Indicate the correct dimension in the space provided.



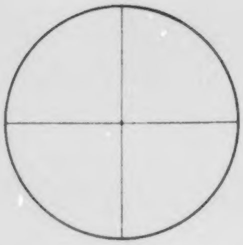
1. ____________



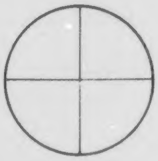
2. ____________



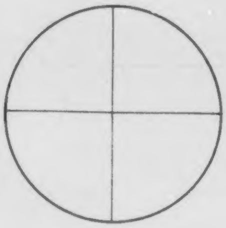
3. ____________



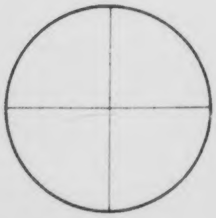
4. ____________



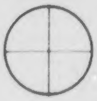
5. ____________



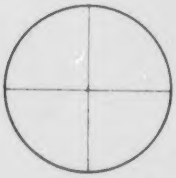
6. ____________



7. ____________



8. ____________



9. ____________

RULES
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #2

1. a. 3 1/4
   b. 4 1/2
   c. 1
   d. 2
2. a. 4 7/8
   b. 2 1/2
   c. 3 5/8
   d. 4 1/4
3. a. 4 5/8
   b. 1 1/16
   c. 2 5/8
   d. 3 1/4
4. a. 4 29/32
   b. 3 15/32
   c. 2
   d. 4 1/16
5. a. 2 3/4
   b. 3 33/64
   c. 4 1/8
   d. 1 33/64
6. a. 3 cm
   b. 6 cm
   c. 1 cm
   d. 12 cm
7. a. 21 mm
   b. 53 mm
   c. 100 mm
   d. 12 mm

Assignment Sheet #3

1. a. 23/32
   b. 19/32
   c. 31/64
   d. 53/64
   e. 19/64
   f. 21/32
   x. 2 5/8
   y. 61/64
2. k. 3/32
   l. 2 1/8
   m. 43/64
   z. 2 57/64
3. e. 55/64
   f. 31/64
   g. 31/64
   h. 51/64
   y. 2 5/8
4. t 51/64
   u. 1 21/32
   v. 51/64
   y. 2 15/64
   z. 3 15/64
   j. 13/32
   i. 13/32
   w. 13/16

Assignment Sheet #4

1. 1 1/2
2. 49/64
3. 37/64
4. 1 23/64
5. 55/64
6. 1 1/4
7. 1 3/16
8. 33/64
9. 31/32

RULES
UNIT I

TEST

1. Match the following terms to the correct definition.

   ______a. Mistake in the reading or total measurement

   ______b. Starting point of measurement for both workpiece and rule

   ______c. Marking found on rules and scales to denote unit of length

   ______d. Accurate or true measurement

   ______e. Semiprecision measuring instrument graduated in fractional or decimal parts of an inch

   1. Steel rule
   2. Graduation
   3. Error
   4. Reliable measure
   5. Reference point

2. Name three basic units of measurement found on rules.

   a.

   b.

   c.

3. List four fractional units of measure found on rules.

   a.

   b.

   c.

   d.

4. List two decimal units found on rules.

   a.

   b.

5. List four metric units found on rules.

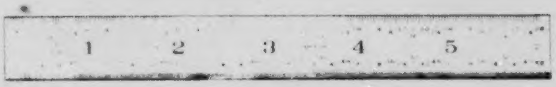
   a.

   b.

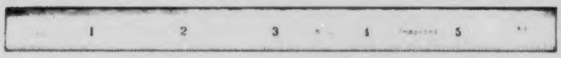
c.

d.

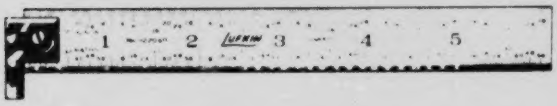
6. Identify the following types of rules.



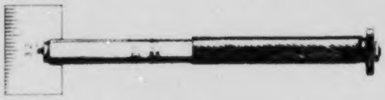
a. ____________



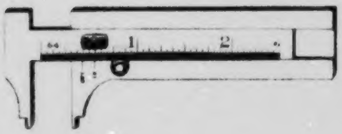
b. ____________


1
2
LUFKIN
3
4
5

c. ____________



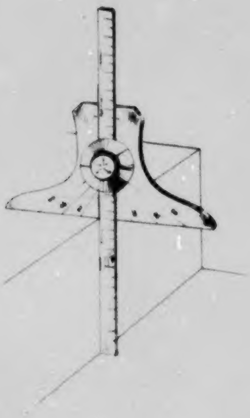
d. ____________



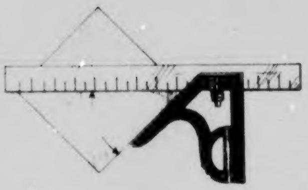
e. ____________

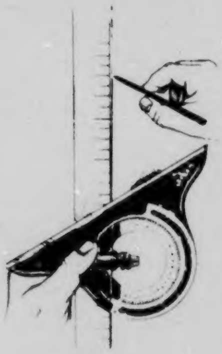
7. Write the uses of the following rules with accessories.

a.

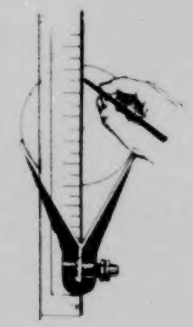


b.

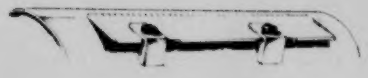




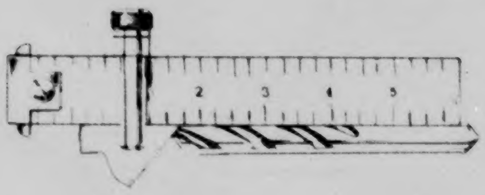
d.



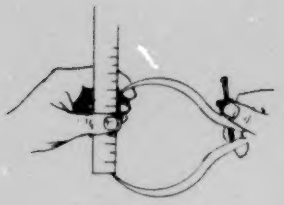
e.



f.



g.



____

____

____

List eight procedures for using rules.

a.

b.

c.

d.

e.

f.

g.

h.

9. List the four steps in reading the rule.

a.

b.

c.

d.

RULES
UNIT I

ANSWERS TO TEST

1. a. 3
   b. 5
   c. 2
   d. 4
   e. 1
2. a. Fractional
   b. Decimal
   c. Metric
3. a. Eighths (1/8")
   b. Sixteenths (1/16")
   c. Thirty-seconds (1/32")
   d. Sixty-fourths (1/64")
4. a. Tenths (0.1)
   b. Hundredths (0.01)
5. a. Meter (1.0 m)
   b. Decimeter (0.1 m)
   c. Centimeter (0.01 m)
   d. Millimeter (0.001 m)
6. a. Steel rule
   b. Narrow flexible rule
   c. Hook rule
   d. Short rule with holder
   e. Slide caliper rule

7. a. Measure depths of grooves, recesses, and shoulders
   b. Lay out and measure lengths from 90° and 45° angles
   c. Lay out and measure lengths of any angle between 0° and 180°
   d. Locate center points on round workpiece
   e. Locate parallel axis and width of key seats
   f. Measure length, drill point angle, and lip length of a drill bit
   g. Measure lengths taken from dividers and calipers
8. a. Use the proper length and graduation
   b. Use finest graduation for accuracy
   c. Use a good quality rule
   d. Do not bend or distort a steel rule
   e. Use only for intended purpose
   f. Use whole unit graduation as reference for accuracy
   g. Use rule on edge for better reading
   h. Use rule along axis parallel to plane of measurement
9. a. Select scale of the required units
   b. Total the number of graduations
   c. Count whole units
   d. Reduce graduations to lowest terms

THE OUTSIDE MICROMETER
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to use, identify, care for, and read the common types of outside micrometers found in the shop. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Select from a list the types of measurements found on outside micrometers.
2. Identify the major parts of an outside micrometer.
3. List steps in selecting the proper size outside micrometer.
4. List rules for use and care of micrometers.
5. Define the term *feel* in using a micrometer.
6. Discuss the proper methods of checking accuracy of a 0" - 1.000" micrometer and a micrometer of more than one inch.
7. Read plain micrometer settings.
8. Read vernier micrometer settings.
9. Demonstrate the ability to:
    a. Use the plain micrometer.
    b. Use the vernier micrometer.

THE OUTSIDE MICROMETER
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information, assignment, and job sheets.

  C. Provide student with appropriate micrometers.

  D. Make transparencies.

  E. Discuss unit and specific objectives.

  F. Discuss information and assignment sheets.

  G. Show films.

  H. Prepare and use supplemental materials if available.

  I. Evaluate assignment sheets.

  J. Demonstrate and discuss procedures outlined in the job sheets.

  K. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete assignment sheets.

  D. Demonstrate the ability to accomplish the procedures outlined in the job sheets.

  E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

C. Transparency masters

  1. TM 1--Micrometer Parts
  2. TM 2--Selecting the Proper Size Micrometer
  3. TM 3--Checking the Micrometer for Accuracy
  4. TM 4--Reading a Micrometer
  5. TM 5--Sleeve Readings

     Overlay A--Thimble Sleeve Readings

     Overlay B--Vernier Sleeve Readings

  6. TM 6--Vernier Micrometer Readings

D. Assignment sheets

  1. Assignment Sheet #1--Read the Plain Micrometer Settings
  2. Assignment Sheet #2--Read the Vernier Micrometer Settings

E. Answers to assignment sheets

F. Job sheets

  1. Job Sheet #1--Use the Plain Micrometer
  2. Job Sheet #2--Use the Vernier Micrometer

G. Test

H. Answers to test

II. References:

A. Ludwig, Oswald A., and McCarthy, Willard J. *Metalwork Technology and Practice.* Bloomington, Illinois: McKnight and McKnight Publishing Co., 1969.

B. McCarthy, Willard J., and Smith, Robert E. *Machine Tool Technology.* Bloomington, Illinois: McKnight and McKnight Publishing Co., 1968.

C. Feirer, John Louis, and Tatro, Earl E. *Machine Tool Metalworking: Principles and Practice.* New York: McGraw-Hill Book Co., Inc., 1961.

D. *How to Read, Use, and Care for Micrometers and Vernier Gauges.* Athol, Massachusetts: L. S. Starrett Co.

E. *The Tools and Rules for Precision Measuring.* Athol, Massachusetts: L. S. Starrett Co.

F. Porter, Harold; Lascoe, O. D.; and Nelson, Clyde. *Machine Shop Operations and Setups.* 3rd ed. Chicago: American Technical Society, 1967.

III. Additional materials:

A. Films:

1. "The Starrett 16mm Movie." L. S. Starrett Company, Athol, Massachusetts.

2. "The Micrometer." OSU Film Library, Oklahoma State University, Stillwater, Oklahoma 74074.

B. Filmstrip--"Micrometer: How It Works; How To Read It." The Jam Handy Organization, Inc.; 2821 East Grand Boulevard; Detroit, Michigan 48211.

THE OUTSIDE MICROMETER
UNIT II

INFORMATION SHEET

I. Types of measurements found on the outside micrometer

  A. Plain measurement--To the nearest thousandth of an inch (0.001")

  B. Vernier measurement--To the nearest ten-thousandth of an inch (0.0001")

II. Major parts of an outside micrometer (Transparency 1)

  A. Frame

  B. Anvil

  C. Spindle

  D. Lock

  E. Sleeve

  F. Thimble

  G. Ratchet stop

III. Steps in selecting the proper size outside micrometer (Transparency 2)

  A. Determine the approximate size of the workpiece

  B. Observe the capacity of the outside micrometer on the frame

  (NOTE: On variable range micrometers, the capacity of the micrometer is located on each anvil.)

IV. General rules for use and care of micrometers

  A. Prevent damage to the instrument

  (NOTE: Keep instrument away from heat, abrasive dust, moisture, oil, and grease.)

  B. Clean and lubricate the instrument occasionally

  C. Check the instrument for accuracy before use

  (NOTE: Observe for worn or loose parts.)

  D. Do not overtighten the instrument during measurement

INFORMATION SHEET

E. Keep instrument and accessories in proper storage and order

F. Handle the instrument in the correct manner

G. Use instrument only for intended purpose

V. Definition of *feel* in using a micrometer--Exactness for the sense of touch between two people on the same measurement

VI. Methods for checking accuracy of outside micrometers (Transparency 3)

A. 0" - 1.000"

1. Close spindle and anvil together

2. Observe zero references on the sleeve and thimble

B. More than one inch

1. Use a standard bar or disc to check the minimum capacity

2. Observe zero references on the sleeve and thimble

VII. Reading the plain micrometer (Transparencies 4, 5, and Overlay A)

A. Each numbered graduation on the sleeve represents one hundred thousandths of an inch (0.100")

B. Each small graduation on the sleeve between the numbered graduations represents twenty-five thousandths of an inch (0.025")

C. Each graduation found on the thimble represents one thousandth of an inch (0.001")

D. Total reading is found by adding the three values

Example:	0.100	Number on the sleeve
	0.075	Small graduations on the sleeve
	0.015	Graduations on the thimble
	0.190	Plain micrometer reading

VIII. Reading the vernier micrometer (Transparencies 6, 5, and Overlays A and B)

A. Each numbered graduation on the sleeve represents one hundred thousandths of an inch (0.100")

B. Each small graduation on the sleeve between the numbered graduations represents twenty-five thousandths of an inch (0.025")

INFORMATION SHEET

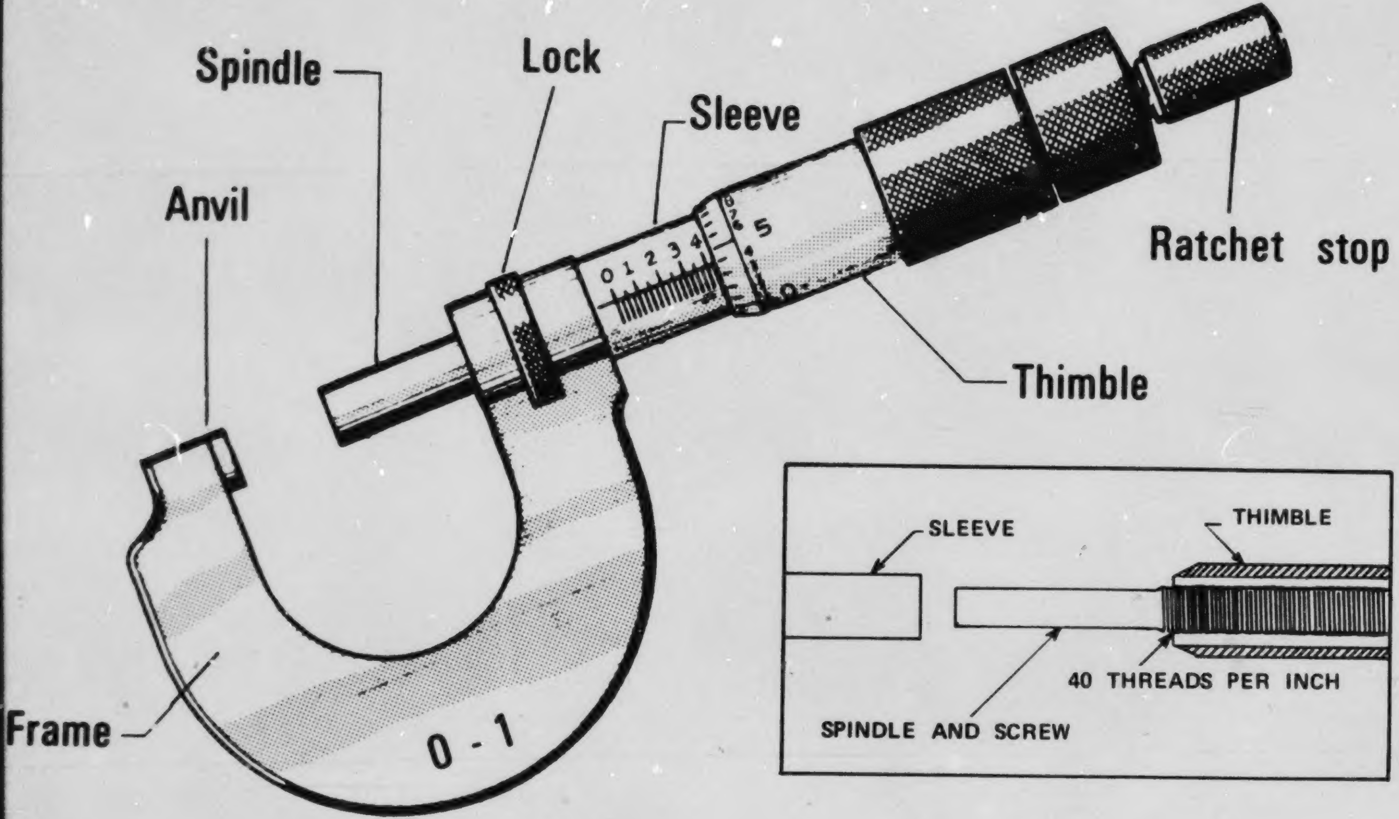
C. Each graduation found on the thimble represents one thousandth of an inch (0.001")

D. Each line graduation found on top of the sleeve represents one ten-thousandth of an inch (0.0001")

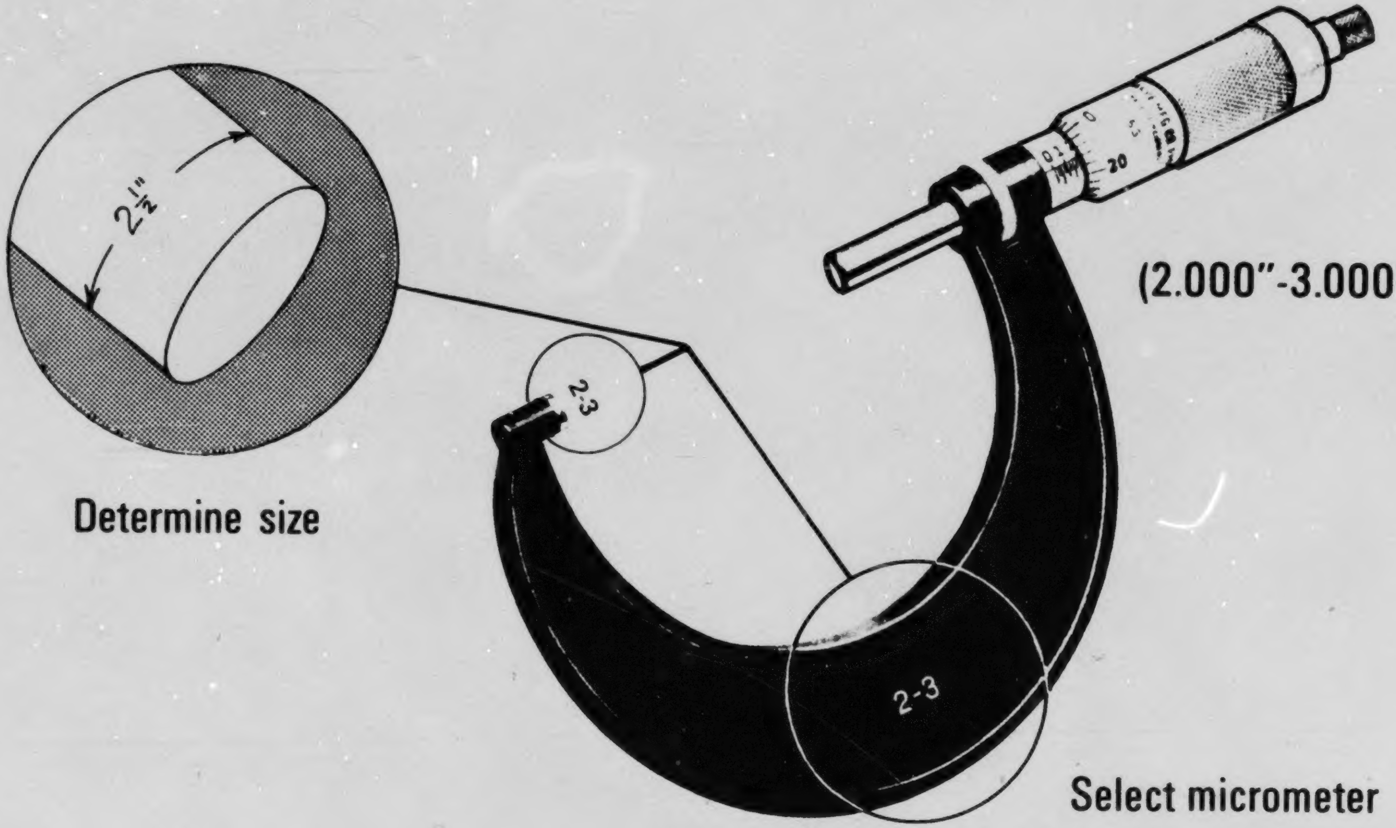
E. Total reading is found by adding the four values

Example:	0.4000	Number on the sleeve
	0.0250	Small graduations on the sleeve
	0.0190	Graduations on the thimble
	0.0006	Vernier scale on top of sleeve
	0.4446	Vernier micrometer reading

Micrometer Parts


Spindle
Lock
Sleeve
Anvil
Ratchet stop
Thimble
Frame
0 - 1
SLEEVE
THIMBLE
40 THREADS PER INCH
SPINDLE AND SCREW

Selecting the Proper Size Micrometer

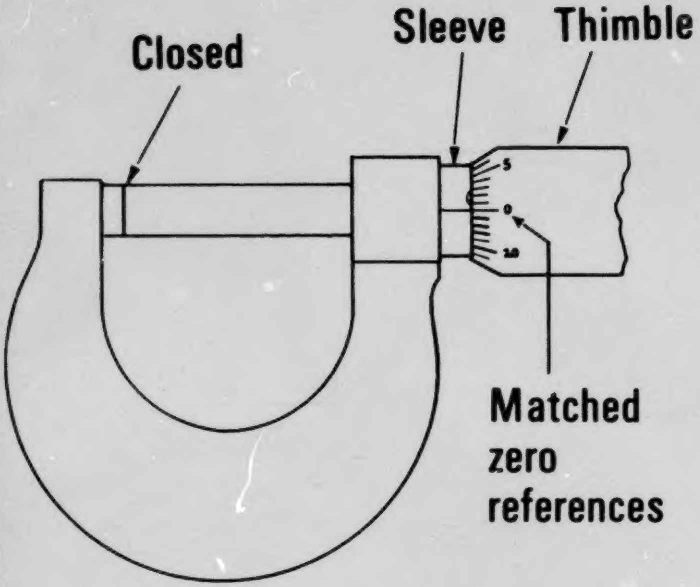


Determine size

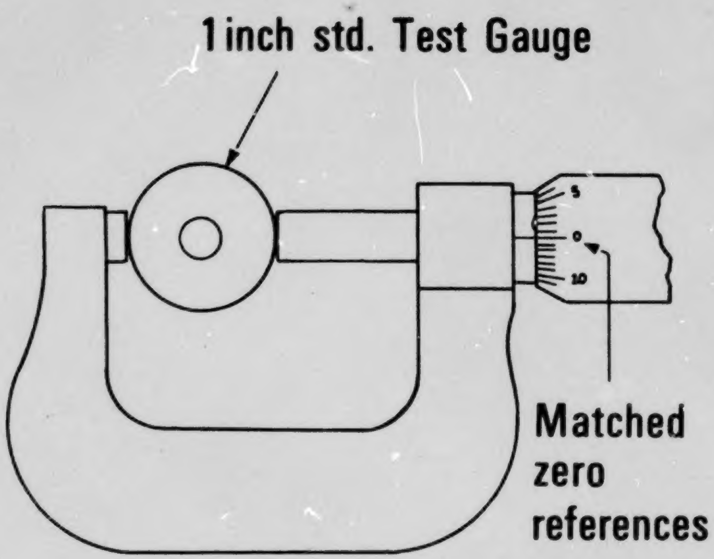
(2.000"-3.000") Size

Select micrometer

Checking the Micrometer for Accuracy


Closed
Sleeve
Thimble
5
0
10
Matched
zero
references

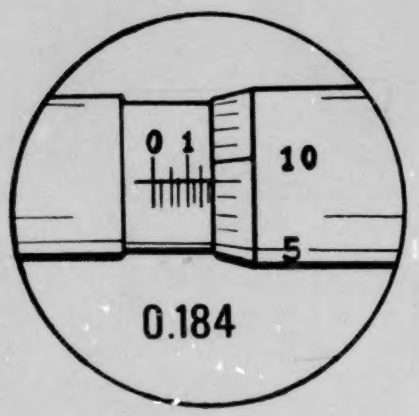
1 INCH MICROMETER


1 inch std. Test Gauge
5
0
10
Matched
zero
references

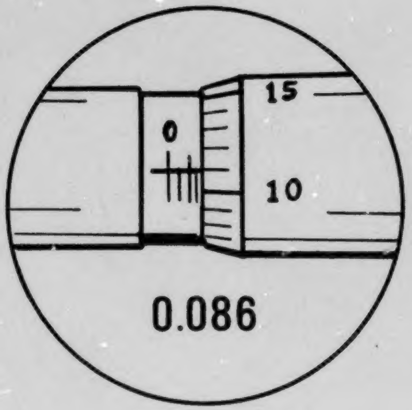
2 INCH MICROMETER

AMT-65-B

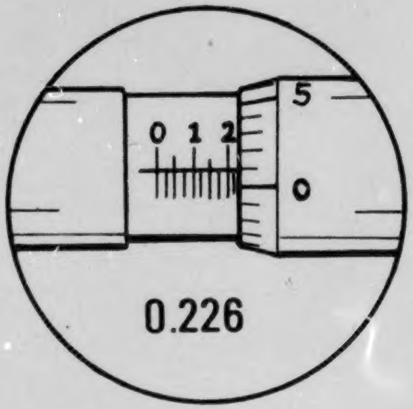
Reading a Micrometer



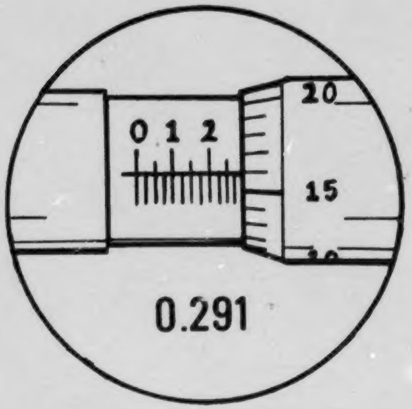
0.184



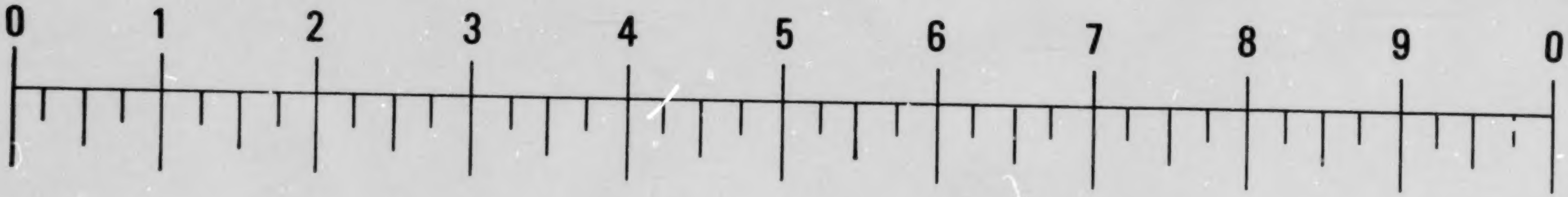
0.086



0.226

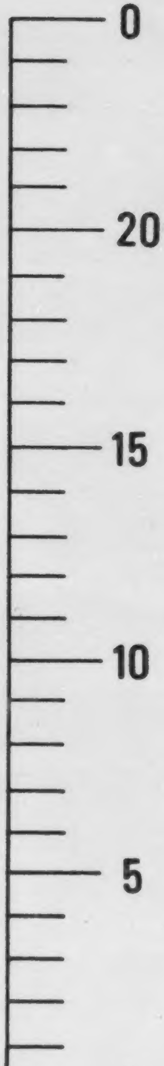


0.291

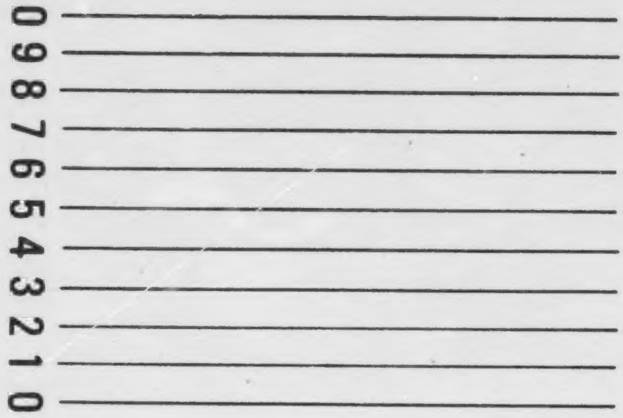

0
1
2
3
4
5
6
7
8
9
0

Sleeve Readings

Thimble Sleeve Readings



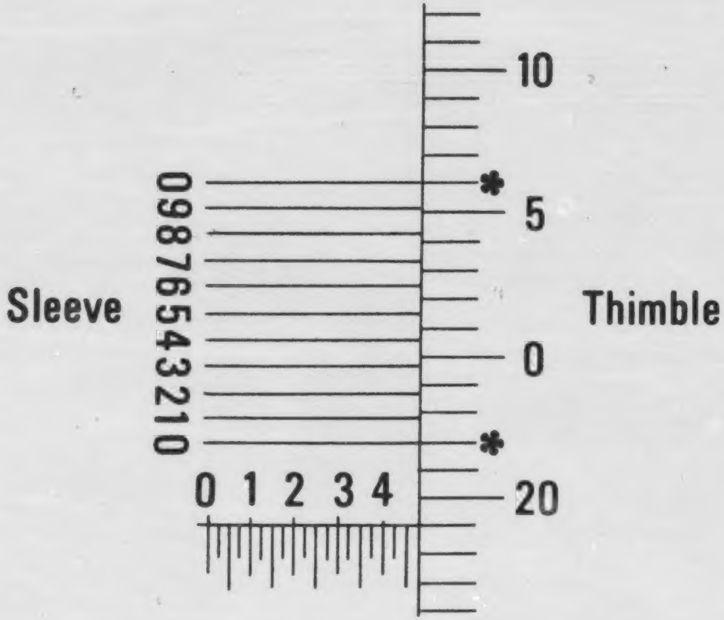
AM I - 71-B


0
9
8
7
6
5
4
3
2
1
0

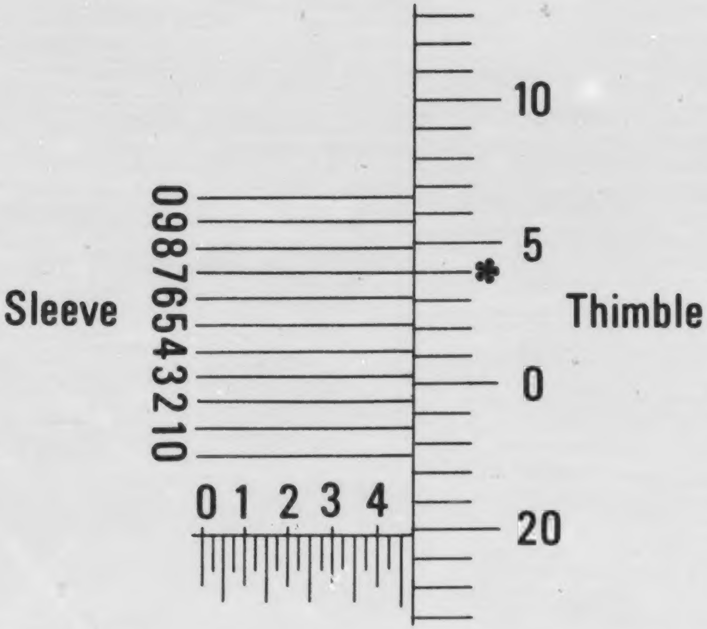
Vernier
Sleeve Readings

AM I - 73-B

Vernier Micrometer Readings


Sleeve
0987654321 0
0 1 2 3 4
Thimble
10
5
0
20
*
*

0.4690


Sleeve
0987654321 0
0 1 2 3 4
Thimble
10
5
0
20
*

0.4697

TM 6

316

316-A

AM I - 75-B

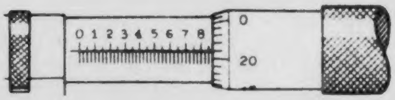
THE OUTSIDE MICROMETER
UNIT II

ASSIGNMENT SHEET #1--READ THE PLAIN MICROMETER SETTINGS

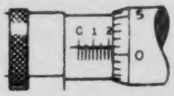
Read the plain micrometer settings below and write the correct answers in the blanks provided.

Answers

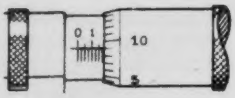
1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______
8. ______
9. ______
10. ______
11. ______
12. ______
13. ______
14. ______
15. ______
16. ______
17. ______
18. ______
19. ______
20. ______


0 1 2 3 4 5 6 7 8
0
20

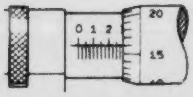
1.



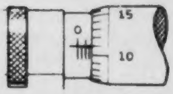
2.



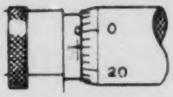
3.



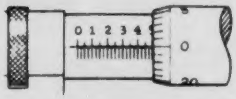
4.



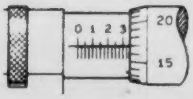
5.



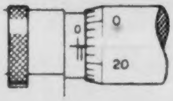
6.



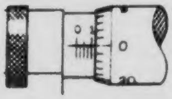
7.



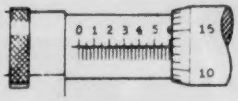
8.



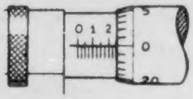
9.



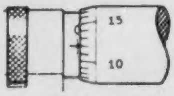
10.


0 1 2 3 4 5
15
10

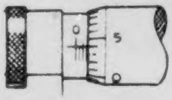
11.



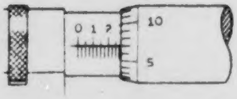
12.



13.



14.



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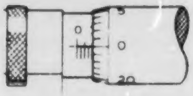

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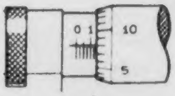
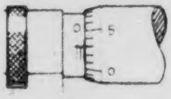
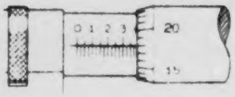


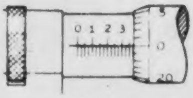
17.



18.



19.



20.

ASSIGNMENT SHEET #1

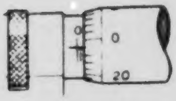
21. ______

22. ______

23. ______

24. ______

25. ______



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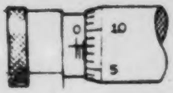

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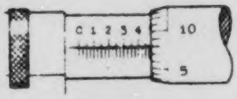
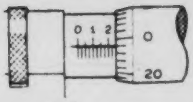
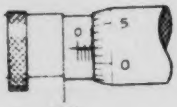


23.



24.



25.

THE OUTSIDE MICROMETER
UNIT II

ASSIGNMENT SHEET #2--READ THE VERNIER MICROMETER SETTINGS

Read the vernier micrometer settings below and write the correct answers in the blanks provided.

Answers

1. ____________

2. ____________

3. ____________

4. ____________

5. ____________

6. ____________

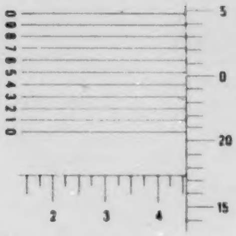
7. ____________

8. ____________

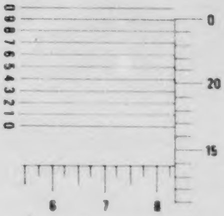
9. ____________

10. ____________

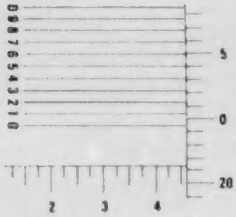
1.


0 9 8 7 6 5 4 3 2 1 0
5
0
20
15
2
3
4

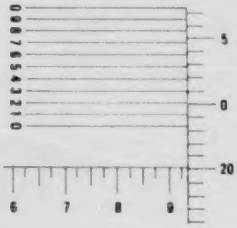
2.


0 9 8 7 6 5 4 3 2 1 0
0
20
15
6
7
8

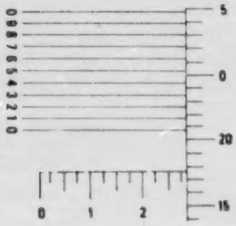
3.


0 9 8 7 6 5 4 3 2 1 0
5
0
20
2
3
4

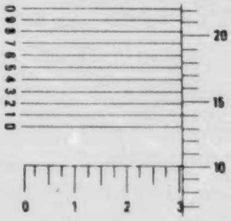
4.


0 9 8 7 6 5 4 3 2 1 0
5
0
20
6
7
8
9

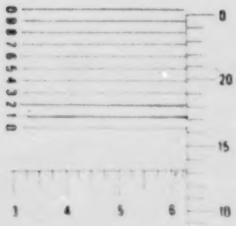
5.


0 9 8 7 6 5 4 3 2 1 0
5
0
20
15
0
1
2

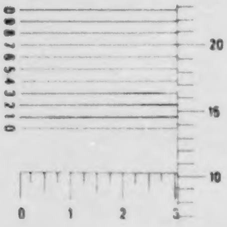
6.


0 9 8 7 6 5 4 3 2 1 0
20
15
10
0
1
2
3

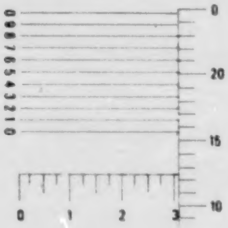
7.


0 9 8 7 6 5 4 3 2 1 0
0
20
15
3
4
5
6
10

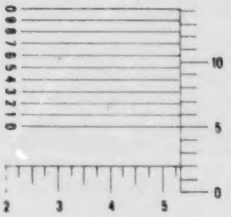
8.


0 9 8 7 6 5 4 3 2 1 0
20
15
10
0
1
2
3

9.


0 9 8 7 6 5 4 3 2 1 0
0
20
15
10
0
1
2
3

10.


0 9 8 7 6 5 4 3 2 1 0
10
5
0
2
3
4
5

THE OUTSIDE MICROMETER
UNIT II

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. 0.871
2. 0.226
3. 0.184
4. 0.291
5. 0.086
6. 0.023
7. 0.500
8. 0.342
9. 0.047
10. 0.125
11. 0.613
12. 0.250
13. 0.012
14. 0.079
15. 0.282
16. 0.100
17. 0.133
18. 0.053
19. 0.393
20. 0.375
21. 0.049
22. 0.058
23. 0.483
24. 0.249
25. 0.102

Assignment Sheet #2

1. 0.4678
2. 0.8388
3. 0.4715
4. 0.9453
5. 0.2928
6. 0.3101
7. 0.6383
8. 0.3107
9. 0.3128
10. 0.5270

THE OUTSIDE MICROMETER
UNIT II

JOB SHEET #1--USE THE PLAIN MICROMETER

I. Tools and equipment

   A. Micrometers, plain

      1. 0" - 1.000" size

      2. 1.000" - 2.000" size

   B. Lathe or vise

   C. Workpieces

      1. New fractional drill bits, assortment of 5

      2. New letter size drill bits, assortment of 5

      3. Pieces of metal such as cold rolled stock, machined parts, hardened dowels; assortment of 5

         (NOTE: All workpieces should be numbered or lettered for reference.)

II. Procedure

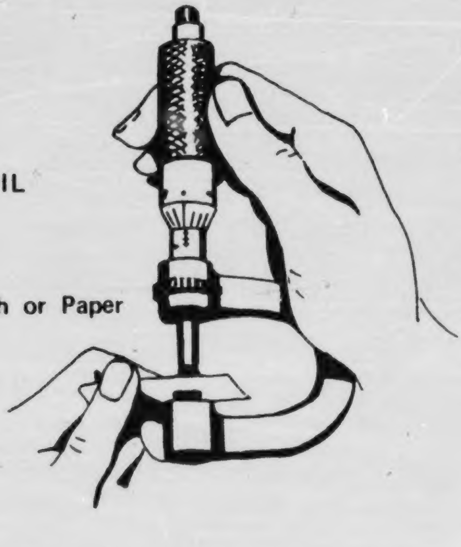
   A. Select workpieces that are clean and free of burrs, nicks, or dents

   B. Select the proper size micrometer for the workpiece

   C. Clean the spindle and anvil of the micrometer (Figure 1)

FIGURE 1

CLEAN SPINDLE AND ANVIL



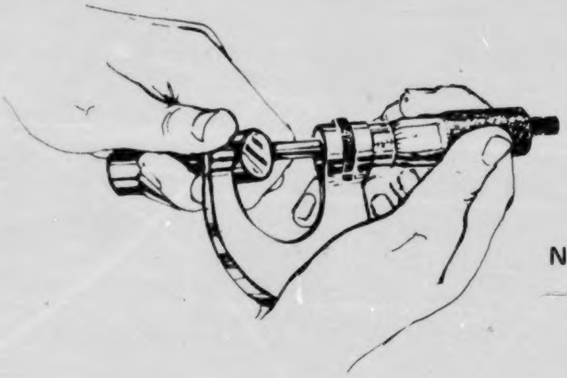
JOB SHEET #1

D. Check the micrometer at zero reference

E. Hold the micrometer according to the type of workpiece

1. Hold the micrometer in the right hand and the workpiece in the left hand to measure a nonstationary object (Figure 2)

FIGURE 2

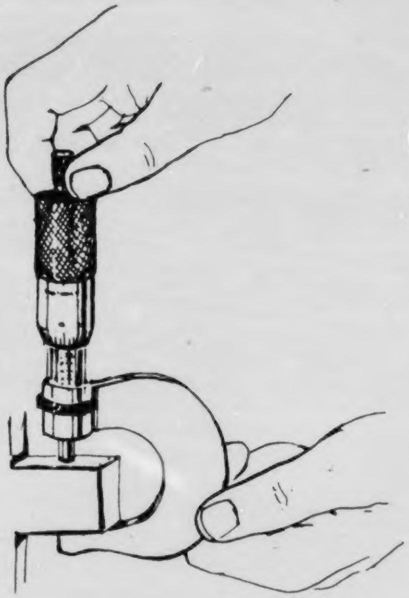


NONSTATIONARY OBJECT

2. Hold the micrometer in both hands to measure a stationary object (Figure 3)

FIGURE 3

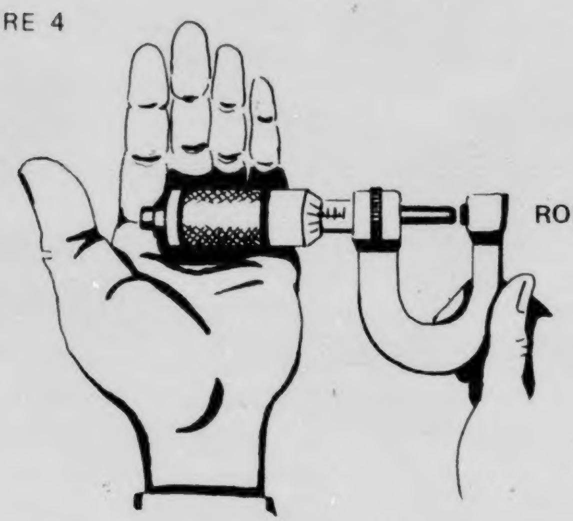
STATIONARY OBJECT



JOB SHEET #1

(NOTE: Roll micrometer along palm of hand or forearm for quick adjustment. See Figure 4.)

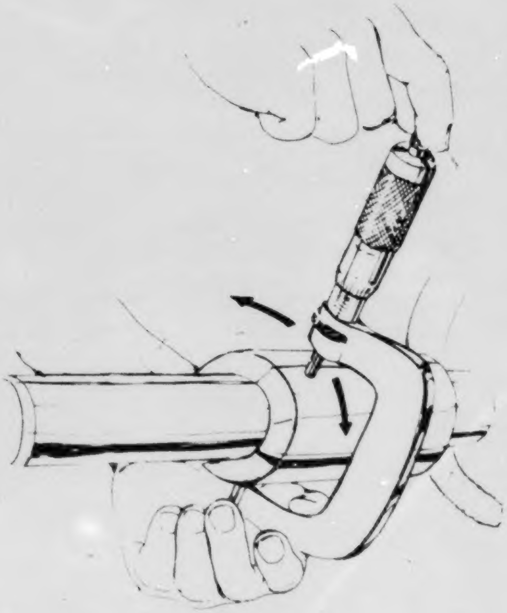
FIGURE 4



ROLL FOR QUICK ADJUSTMENT

F. Place the micrometer directly over the center of the workpiece to be measured (Figure 5)

FIGURE 5



WORK BACK AND FORTH TO FIND TRUE DIAMETER

JOB SHEET #1

G. Turn the thimble of the micrometer until the anvil and spindle contact the workpiece

H. Hold the anvil steady and move the spindle lightly over the workpiece to locate the true centerline

(NOTE: See Figure 5 on the preceding page.)

I. Use ratchet stop or light sense of *feel* to determine exact measurement

J. Observe micrometer readings

(NOTE: Spindle lock can be turned to hold measurement if micrometer must be removed from workpiece. Spindle must be unlocked before resetting to a new measurement.)

K. List the readings according to the letter or number on the workpiece

L. Return the micrometer to its correct storage

(NOTE: The spindle and anvil of the micrometer should be left open when stored.)

M. Hand in the listed readings to the instructor for evaluation

THE OUTSIDE MICROMETER
UNIT II

JOB SHEET #2--USE THE VERNIER MICROMETER

I. Tools and equipment

- A. Micrometers, vernier
  - 1. 0" - 1.000" size
  - 2. 1.000" - 2.000" size
- B. Lathe or vise
- C. Workpieces
  - 1. New number drill bits, assortment of 5
  - 2. New fractional drill bits, assortment of 5
  - 3. Pieces of metal such as cold rolled stock, machined parts, hardened dowels; assortment of 5

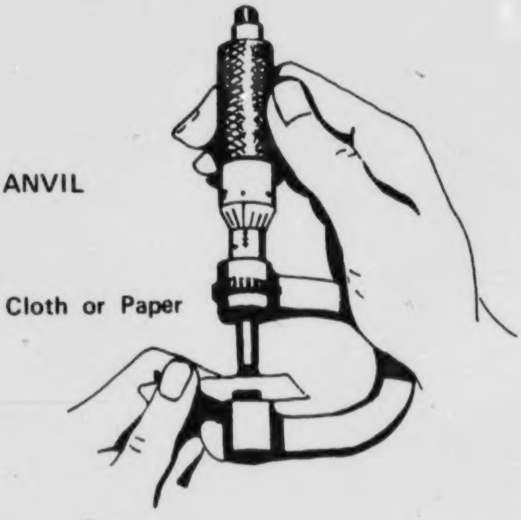
    (NOTE: All workpieces should be numbered or lettered for reference.)

II. Procedure

- A. Select workpieces that are clean and free of burrs, nicks, or dents
- B. Select the proper size micrometer for the workpiece
- C. Clean the spindle and anvil of the micrometer (Figure 1)

FIGURE 1

CLEAN SPINDLE AND ANVIL



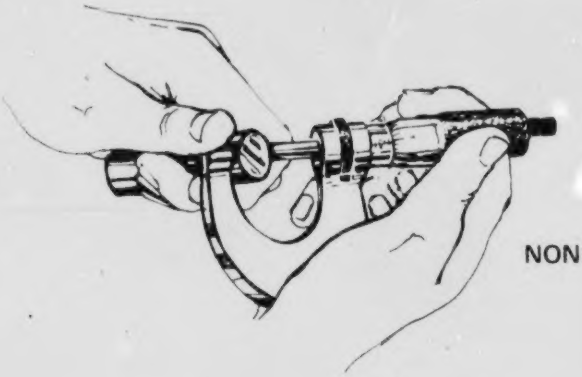
JOB SHEET #2

D. Check the micrometer at zero reference

E. Hold the micrometer according to the type of workpiece

1. Hold the micrometer in the right hand and the workpiece in the left hand to measure a nonstationary object (Figure 2)

FIGURE 2

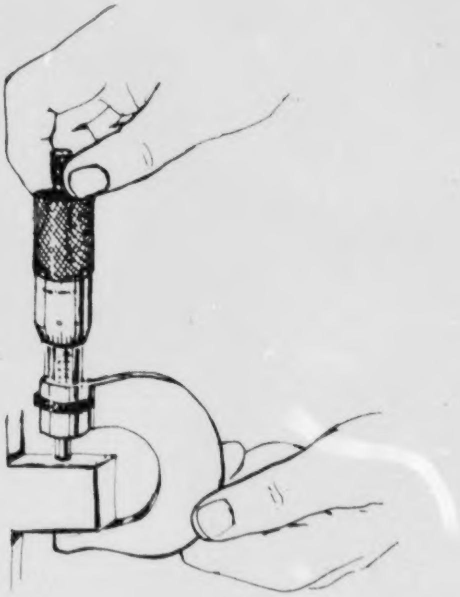


NONSTATIONARY OBJECT

2. Hold the micrometer in both hands to measure a stationary object (Figure 3)

FIGURE 3

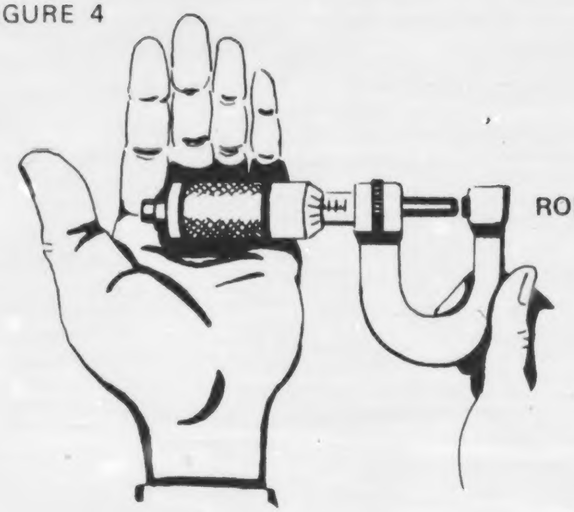
STATIONARY OBJECT



JOB SHEET #2

(NOTE: Roll micrometer along palm of hand or forearm for quick adjustment. See Figure 4.)

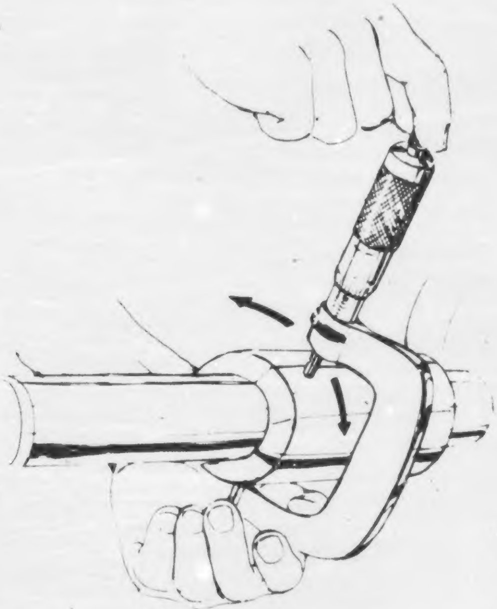
FIGURE 4



ROLL FOR QUICK ADJUSTMENT

F. Place the micrometer directly over the center of the workpiece to be measured (Figure 5)

FIGURE 5



WORK BACK AND FORTH TO FIND TRUE DIAMETER

JOB SHEET #2

G. Turn the thimble of the micrometer until the anvil and spindle contact the workpiece

H. Hold the anvil steady and move the spindle lightly over the workpiece to locate the true centerline

(NOTE: See Figure 5 on the preceding page.)

I. Use ratchet stop or light sense of *feel* to determine exact measurement

J. Observe micrometer readings

(NOTE: Spindle lock can be turned to hold measurement if micrometer must be removed from workpiece. Spindle must be unlocked before resetting to a new measurement.)

K. List the readings according to the letter or number on the workpiece

L. Return the micrometer to its correct storage

(NOTE: The spindle and anvil of the micrometer should be left open when stored.)

M. Hand in the listed readings to the instructor for evaluation

THE OUTSIDE MICROMETER
UNIT II

TEST

1. Select from the list below the two types of measurements found on outside micrometers by placing an "X" in the correct blanks.

______a. Plain measurement--To the nearest thousandth of an inch

______b. Conventional measurement--To the nearest hundredth of an inch

______c. Vernier measurement--To the nearest ten-thousandth of an inch

______d. Universal measurement--To the nearest millimeter

______e. Rule measurement--To the nearest sixty-fourth of an inch

2. Identify the seven major parts of the outside micrometer in the diagram below by writing the correct names in the blanks.

a.____________

b.____________

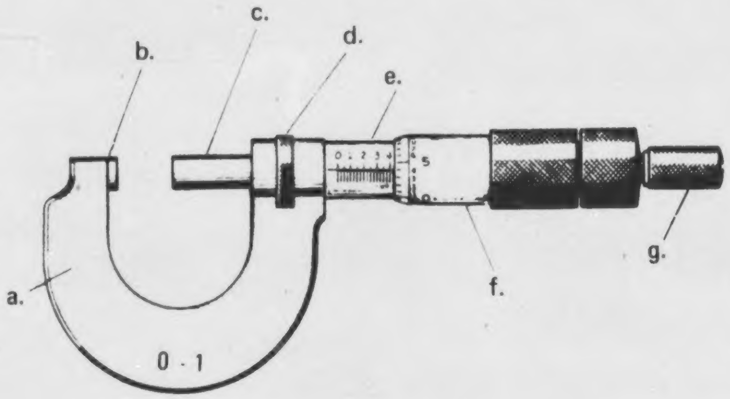
c.____________

d.____________

e.____________

f.____________

g.____________



3. List two steps in selecting the proper size outside micrometer.

a.

b.

4. List seven rules for use and care of micrometers.

a.

b.

c.

d.

e.

f.

g.

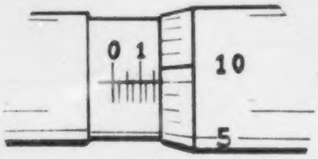
5. Define the term *feel* in using a micrometer.

6. Discuss methods for checking micrometer accuracy.

    a. The 0" - 1.000" micrometer

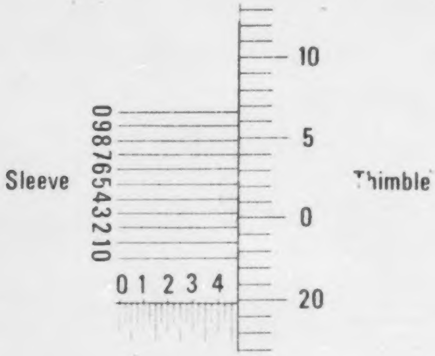
    b. Micrometers larger than one inch

7. Read the following plain micrometer setting.



Answer___________

8. Read the following vernier micrometer setting.


10
5
0
20
0987654321 0
0 1 2 3 4
Sleeve
Thimble

Answer___________

9. Demonstrate the ability to:

   a. Use the plain micrometer.

   b. Use the vernier micrometer.

   (NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

THE OUTSIDE MICROMETER
UNIT II

ANSWERS TO TEST

1. a, c

2. a. Frame
   b. Anvil
   c. Spindle
   d. Lock
   e. Sleeve
   f. Thimble
   g. Ratchet stop

3. a. Determine the approximate size of the workpiece
   b. Observe the capacity of the outside micrometer on the frame

4. a. Prevent damage to the instrument
   b. Clean and lubricate the instrument occasionally
   c. Check the instrument for accuracy before use
   d. Do not overtighten the instrument during measurement
   e. Keep instrument and accessories in proper storage and order
   f. Handle the instrument in the correct manner
   g. Use instrument only for intended purpose

5. *Feel*--Exactness for the sense of touch between two people on the same measurement

6. a. 0" - 1.000"
      1) Close spindle and anvil together
      2) Observe zero references on the sleeve and thimble
   b. More than one inch
      1) Use a standard bar or disc to check the minimum capacity

2) Observe zero references on the sleeve and thimble

7. 0.159

8. 0.4697

9. Performance skills will be evaluated to the satisfaction of the instructor.

THE INSIDE MICROMETER
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify, read, and use the inside micrometer. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Identify the parts of an inside micrometer.
2. List uses of the inside micrometer.
3. Identify accessories used with the inside micrometer.
4. List rules for use and care of micrometers.
5. List methods for checking the accuracy of an inside micrometer.
6. Read plain micrometer settings.
7. Demonstrate the ability to use the inside micrometer.

THE INSIDE MICROMETER
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information, assignment, and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Prepare and use supplemental materials if available.

   G. Evaluate assignment sheet.

   H. Demonstrate and discuss the procedure outlined in the job sheet.

   I. Give test.

II. Student:

   A. Read the objective sheet.

   B. Study the information sheet.

   C. Complete the assignment sheet.

   D. Demonstrate the ability to accomplish the procedure outlined in the job sheet.

   E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Parts of the Inside Micrometer

   2. TM 2--Uses of the Inside Micrometer
   3. TM 3--Uses of the Inside Micrometer (Continued)
   4. TM 4--Inside Micrometer Set
   5. TM 5--Methods for Checking Accuracy of Inside Micrometers
   6. TM 6--Reading a Micrometer

D. Assignment Sheet #1--Read the Inside Micrometer Settings

E. Answers to assignment sheet

F. Job Sheet #1--Use the Inside Micrometer

G. Test

H. Answers to test

II. References:

A. Ludwig, Oswald A., and McCarthy, Willard J. *Metalwork Technology and Practice.* Bloomington, Illinois: McKnight and McKnight Publishing Co., 1969.

B. Walker, John. *Machining Fundamentals.* Homewood, Illinois: Goodheart-Willcox Co., 1969.

C. McCarthy, Willard J., and Smith, Robert E. *Machine Tool Technology.* Bloomington, Illinois: McKnight and McKnight Publishing Co., 1968.

D. Johnson, Harold V. *General-Industrial Machine Shop.* rev. Peoria, Illinois: Charles Bennett Publishing Co., 1970.

E. Porter, Harold; Lascoe, O. D.; and Nelson, Clyde. *Machine Shop Operations and Setups.* 3rd ed. Chicago: American Technical Society, 1967.

F. Busch, Ted. *Fundamentals of Dimensional Metrology.* Albany 5, New York: Wilkie Brothers Foundation, Delmar Publishers, Inc., 1964.

III. Additional materials:

A. Film--"The Micrometer." OSU Film Library, Oklahoma State University, Stillwater, Oklahoma 74074.

B. Filmstrip--"Measurements and Measuring." Series no. 2120. The Jam Handy Organization, Inc.; 2821 East Grand Boulevard; Detroit, Michigan 48211.

THE INSIDE MICROMETER
UNIT III

INFORMATION SHEET

I. Parts of the inside micrometer (Transparency 1)

  A. Body

  B. Anvil

  C. Thimble

  D. Handle

  E. Rod

  F. Lock screw

II. Uses of the inside micrometer

  A. Measure inside diameter (Transparency 2)

  Examples: Drilled holes, bored holes, reamed holes

  B. Measure width (Transparency 2)

  Examples: Slots, grooves

  C. Measure height (Transparency 3)

  (NOTE: A base attachment should be used.)

  D. Transfer measurement to outside spring-joint caliper (Transparency 3)

III. Accessories used with the inside micrometer (Transparency 4)

  A. Extension rod

  (NOTE: The rod extends the measuring capacity of the base unit.)

  B. Extension collar

  (NOTE: The extension collar locks the extension rod to the base unit and extends the measuring capacity by 0.500".)

INFORMATION SHEET

C. Extension handle

(NOTE: Hard-to-reach places can be measured more easily when an extension handle is used.)

D. Base unit

(NOTE: Base units come in various ranges of measurement.)

E. Height gauge base

(NOTE: The base enables the micrometer to be used for inspection or setup work.)

F. Wrench

(NOTE: The wrench is used to adjust accuracy of micrometer.)

IV. Rules for use and care of micrometers

A. Prevent damage to the instrument

(NOTE: Keep instrument away from heat, abrasive dust, moisture, oil, and grease.)

B. Clean and lubricate the instrument occasionally

C. Check the instrument for accuracy before use

(NOTE: Observe for worn or loose parts.)

D. Do not overtighten the instrument during measurement

E. Keep instrument and accessories in proper storage and order

F. Handle the instrument in the correct manner

G. Use instrument only for intended purpose

V. Methods for checking the accuracy of the inside micrometer (Transparency 5)

A. Measure the zero reference of an inside micrometer with an accurate outside micrometer

B. Measure an object of known accurate measurement or use a standard ring gauge

C. Use a gauge block holder and gauge blocks to check an extension bar measurement

INFORMATION SHEET

VI. Reading the plain micrometer (Transparency 6)

A. Each numbered division on the sleeve represents one hundred thousandths of an inch (0.100")

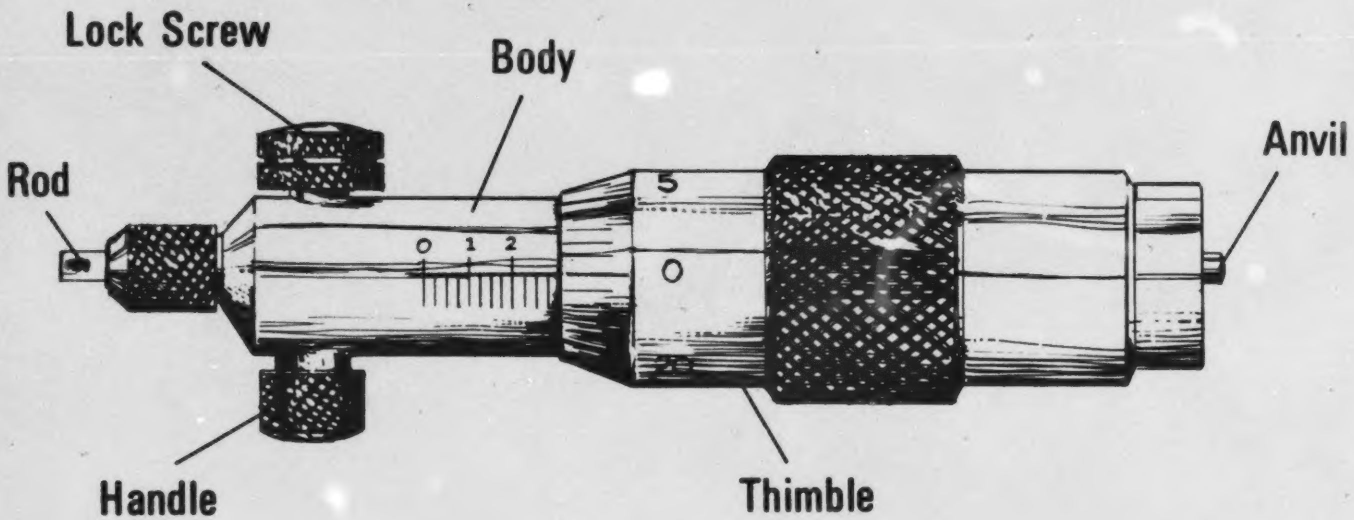
B. Each small graduation on the sleeve between the numbered graduations represents twenty-five thousandths of an inch (0.025")

C. Each graduation found on the thimble represents one thousandth of an inch (0.001")

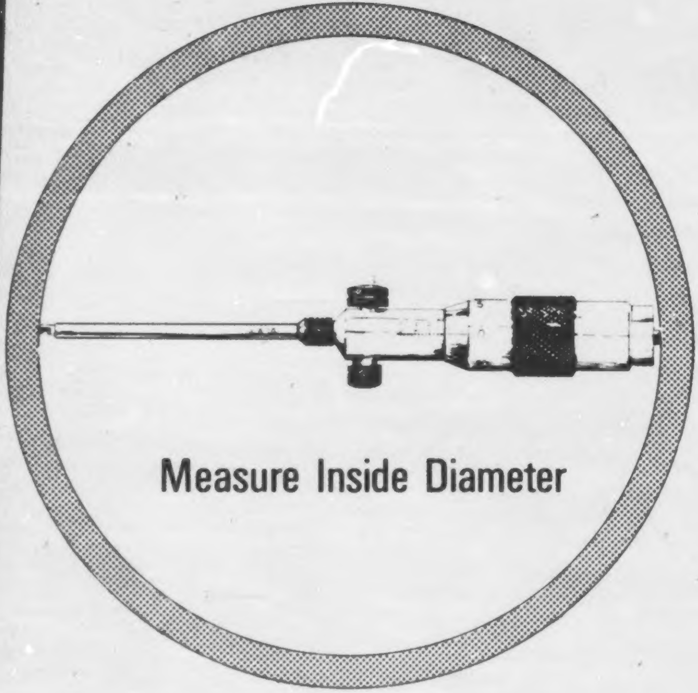
D. Reading is totaled by adding the three values

Example:
0.300--Number on the sleeve
0.050--Small graduations on the sleeve
0.012--Graduations on the thimble
0.362--Plain micrometer reading

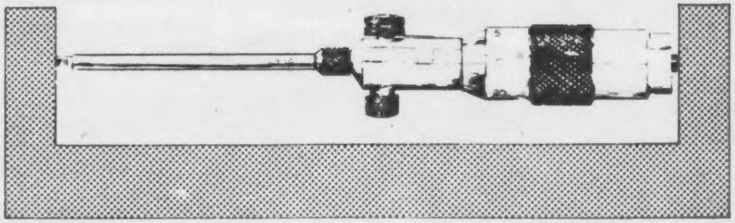
Parts of the Inside Micrometer


Lock Screw
Body
Anvil
Rod
5
0 1 2
0
20
Handle
Thimble

Uses of the Inside Micrometer



Measure Inside Diameter

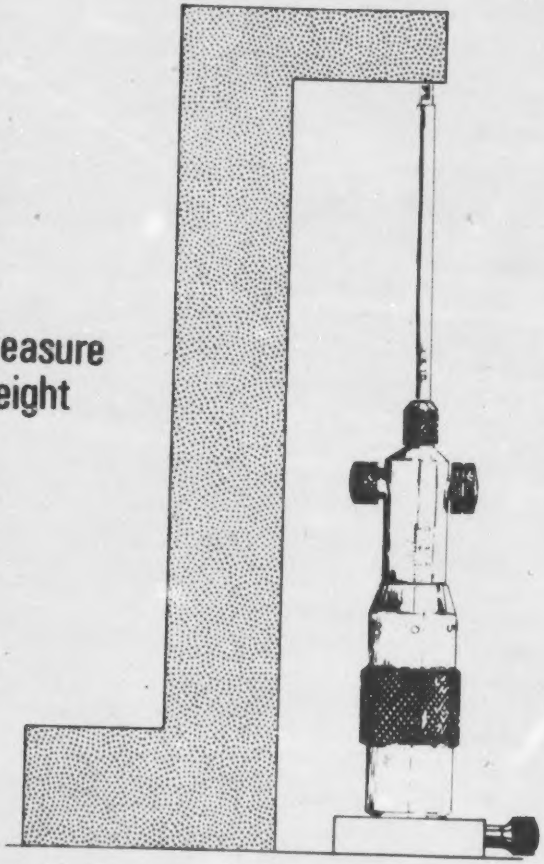


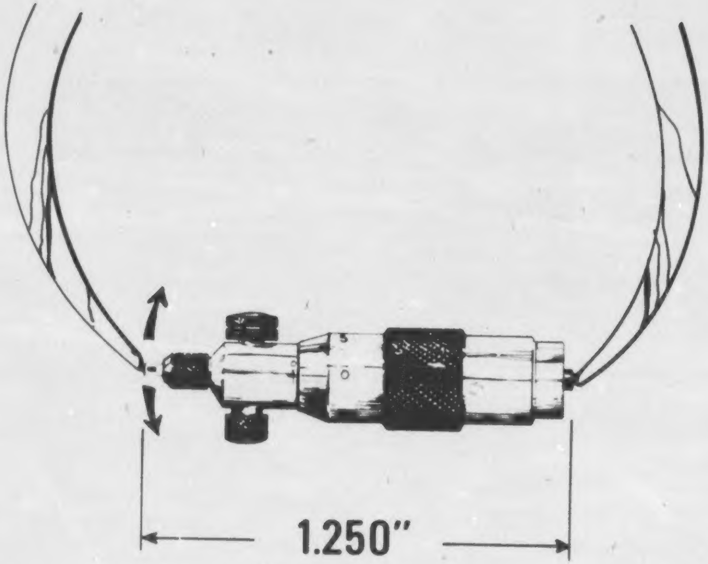
Measure Width

Uses of the Inside Micrometer

(Continued)

Measure Height

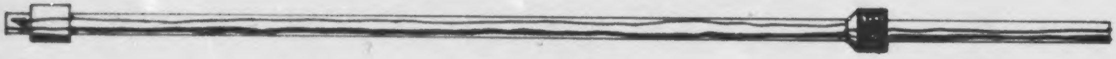


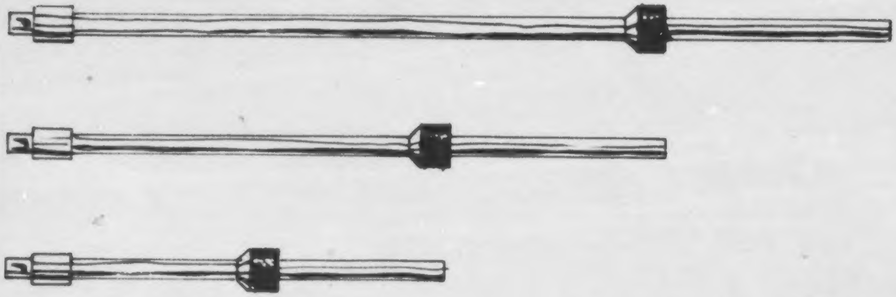


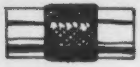
Transfer Measurement to Outside Spring-Joint Caliper

Inside Micrometer Set

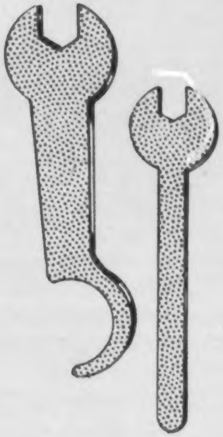
Extension Rods



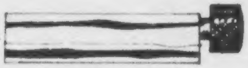




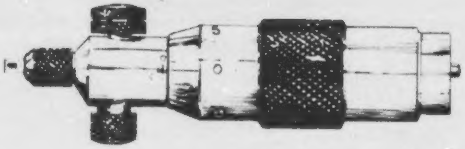
Extension Collar



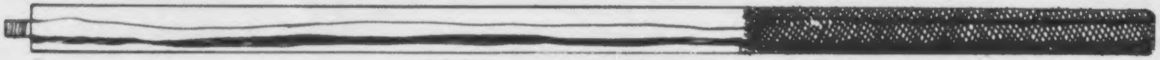
Wrenches



Height Gauge Base

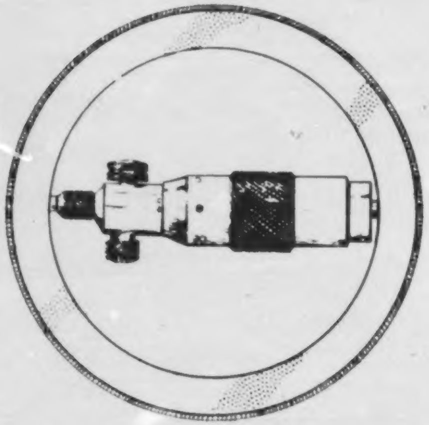


Base Unit

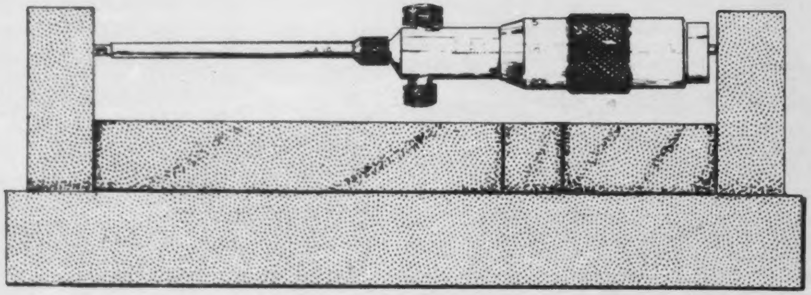


Extension Handle

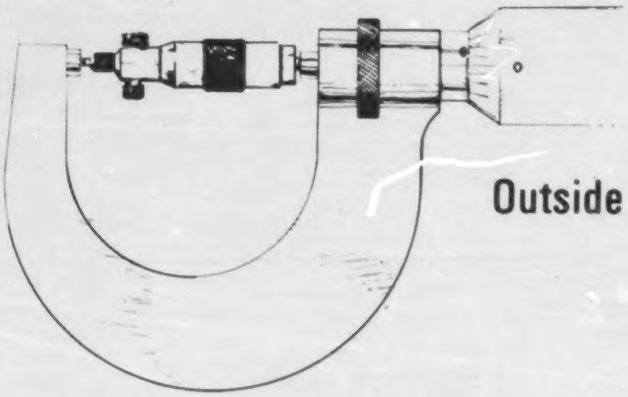
Methods for Checking Accuracy of Inside Micrometers



Ring Gauge Method

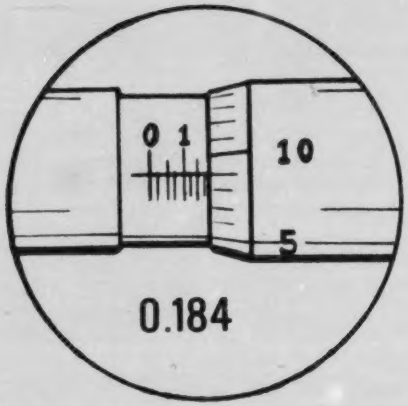


Gauge and Block Method

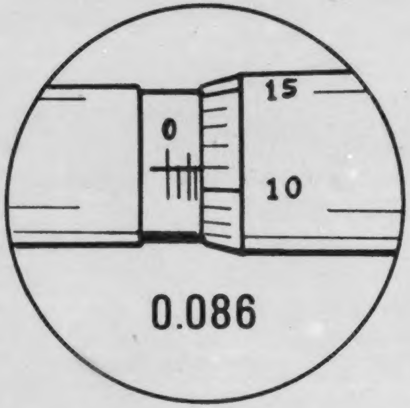


Outside Micrometer Method

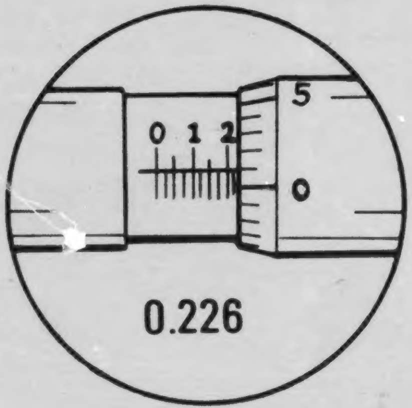
Reading a Micrometer



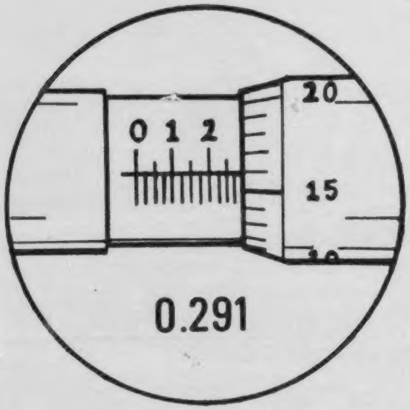
0.184



0.086



0.226

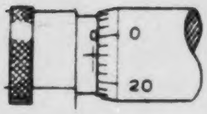


0.291

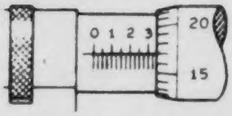
THE INSIDE MICROMETER
UNIT III

ASSIGNMENT SHEET #1--READ THE INSIDE MICROMETER SETTINGS

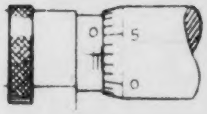
Read the following inside micrometer settings and record your answer under each picture.



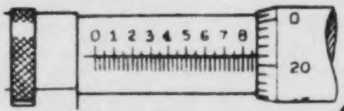
1



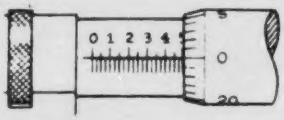
2



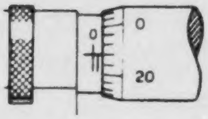
3


0 1 2 3 4 5 6 7 8
0
20

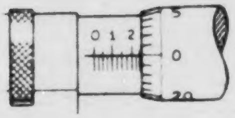
4


0 1 2 3 4 5
5
0
20

5



6



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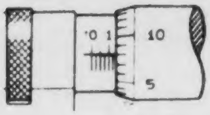

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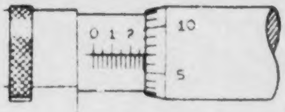

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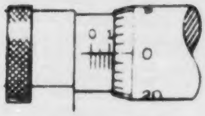


10

THE INSIDE MICROMETER
UNIT III

ANSWERS TO ASSIGNMENT SHEET

1. 0.023
2. 0.342
3. 0.053
4. 0.871
5. 0.500
6. 0.047
7. 0.250
8. 0.133
9. 0.282
10. 0.125

THE INSIDE MICROMETER
UNIT III

JOB SHEET #1--USE THE INSIDE MICROMETER

I. Materials

A. Inside micrometer set

(NOTE: Set should include extension bars, extension collars, base units, and tools for assembly.)

B. Bored or drilled holes or pipe rings, assortment of 10 in varying sizes

(NOTE: All workpieces should be numbered or lettered for reference.)

II. Procedure

A. Select workpieces that are clean and free of burrs, nicks, or dents

B. Clean the contact point and accessories of the inside micrometer

C. Check micrometer accuracy

D. Select the correct extension rod and collar for the required measurement

1. Observe base unit size and range of movement

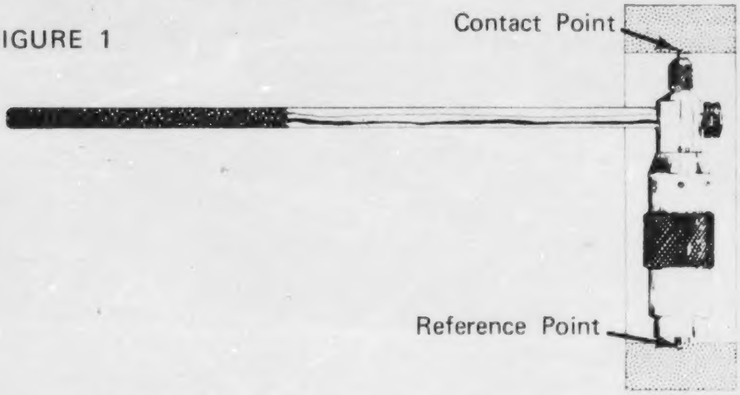
Example: A 2.000" base unit with a 0.500" movement measures from 2.000" to 2.500"

2. Add extension collar to utilize full range of extension rod

3. Use tools to assemble and disassemble accessories

E. Establish a good reference and contact point during measurement (Figure 1)

FIGURE 1



(NOTE: Support inside micrometer in a comfortable position during use. Add extension handle for small hole or deep hole application.)

JOB SHEET #1

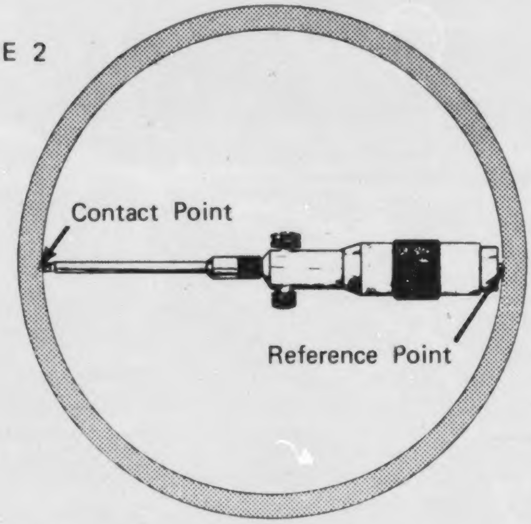
F. Move the contact point from side to side to find the true diameter of the workpiece (Figure 1)

(NOTE: Use light sense of *feel* on the thimble of the base unit.)

G. Observe the total reading from the base unit of the inside micrometer

(NOTE: Add extension rod and/or extension collar to the total measurement. See Figure 2.)

FIGURE 2



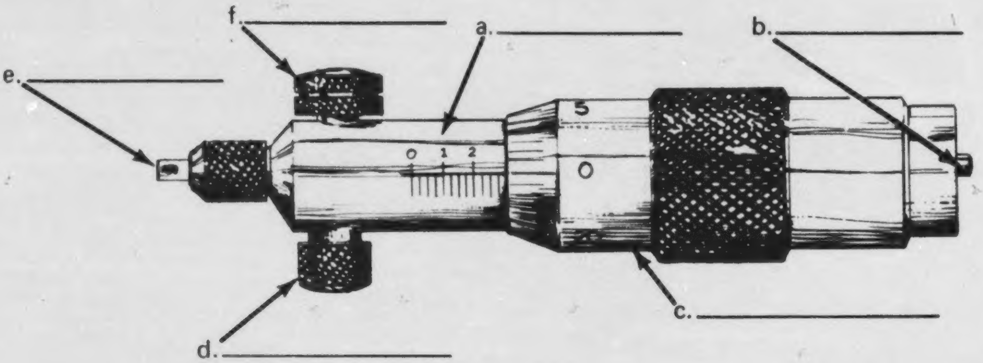
H. List the readings according to the letter or number on the workpiece

I. Replace the inside micrometer set in original order after use

THE INSIDE MICROMETER
UNIT III

TEST

1. Identify the basic parts of the inside micrometer in the diagram below by writing the correct names in the blanks.



2. List four uses of the inside micrometer.

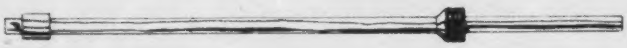
   a.

   b.

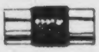
   c.

   d.

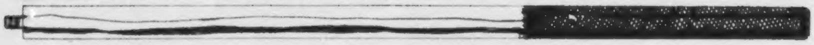
3. Identify the following accessories used with the inside micrometer by writing the correct names in the blanks.



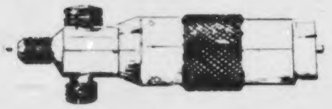
a. ______________________________



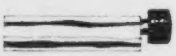
b. ______________________



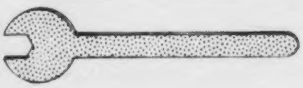
c. ______________________________



d. ______________________________



e. ______________________



f. ______________________

4. List seven rules for use and care of micrometers.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

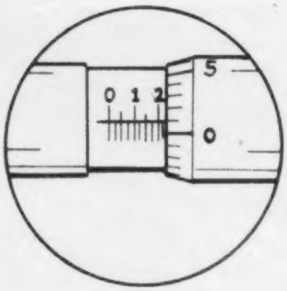
5. List three methods for checking the accuracy of an inside micrometer.

   a.

   b.

   c.

6. Read the following plain micrometer setting.



Answer ___________

7. Demonstrate the ability to use the inside micrometer.

(NOTE: If this has not been accomplished prior to the test, ask the instructor when the above activity should be completed.)

THE INSIDE MICROMETER
UNIT III

ANSWERS TO TEST

1. a. Body
   b. Anvil
   c. Thimble
   d. Handle
   e. Rod
   f. Lock screw
2. a. Measure inside diameter
   b. Measure width
   c. Measure height
   d. Transfer measurement to outside spring-joint caliper
3. a. Extension rod
   b. Extension collar
   c. Extension handle
   d. Base unit
   e. Height gauge base
   f. Wrench
4. a. Prevent damage to the instrument
   b. Clean and lubricate the instrument occasionally
   c. Check the instrument for accuracy before use
   d. Do not overtighten the instrument during measurement
   e. Keep instrument and accessories in proper storage and order
   f. Handle the instrument in the correct manner
   g. Use instrument only for intended purpose

5.
   a. Measure the zero reference of an inside micrometer with an accurate outside micrometer

   b. Measure an object of known accurate measurement or use a standard ring gauge

   c. Use a gauge block holder and gauge blocks to check an extension bar measurement

6. 0.226

7. Performance skills will be evaluated to the satisfaction of the instructor.

[redacted]

BASIC ENGINE PRINCIPLES
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to list the characteristics, types, and forms of energy and calculate problems dealing with work, horsepower, torque, and cubic inch displacement. The student should be able to distinguish between internal and external combustion engines and describe the operation of two-stroke and four-stroke cycle engines. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with basic engine principles to the correct definitions.
2. Discuss characteristics of energy.
3. List types of energy.
4. List forms of available energy.
5. List the types of motion.
6. Identify types of simple machines.
7. List the uses of simple machines.
8. Calculate problems using the formula for work.
9. Calculate problems using the formula for horsepower.
10. Calculate problems using the formula for torque.
11. Describe the characteristic of heat engines.
12. Distinguish between external and internal combustion engines.
13. Match the parts of a basic internal combustion engine to the correct descriptions.
14. Describe the process by which an automobile engine converts chemical energy into rotary motion.
15. Discuss the operation of a four-stroke cycle engine.

16. Discuss specific valve timing and valve overlap.

17. Discuss the operation of a two-stroke cycle engine beginning with the piston positioned at the bottom of the cylinder.

18. State the formula for calculating engine cubic inch displacement.

19. Explain the results of increasing the compression ratio.

20. Identify the components of an automobile engine.

21. Distinguish between gasoline and diesel engines.

22. Discuss the purposes of a heavy flywheel.

BASIC ENGINE PRINCIPLES
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and assignment sheets.

  C. Make transparencies.

  D. Check with the major automobile manufacturers for visual aids to demonstrate basic engine principles.

  E. Discuss unit and specific objectives.

  F. Discuss information and assignment sheets.

  G. Give test.

II. Student:

  A. Read objective sheet.

  B. Read and study information sheet.

  C. Complete activities outlined on assignment sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Types of Motion

    2. TM 2--The Principle of the Lever

    3. TM 3--The Principle of the Wheel and Axle

4. TM 4--The Principle of the Pulley
5. TM 5--The Principle of the Inclined Plane
6. TM 6--The Principle of the Screw
7. TM 7--The Principle of the Wedge
8. TM 8--Basic Internal Combustion Engine Parts
9. TM 9--Chemical Energy to Rotary Motion
10. TM 10--Four-Stroke Cycle
11. TM 11--Valve Timing and Overlap
12. TM 12--Two-Stroke Cycle
13. TM 13--Cubic Inch Displacement
14. TM 14--Compression Ratio
15. TM 15--Components of an Automobile Engine

D. Assignment sheets

1. Assignment Sheet #1--Calculate Work
2. Assignment Sheet #2--Calculate Horsepower
3. Assignment Sheet #3--Calculate Torque
4. Assignment Sheet #4--Calculate Cubic Inch Displacement

E. Answers to assignment sheets

F. Test

G. Answers to test

II. References:

A. Bohn, Ralph C., and MacDonald, Angus J. *Power: Mechanics of Energy Control.* Bloomington, Illinois: McKnight and McKnight, 1970.

B. Stockel, Martin W. *Auto Mechanics Fundamentals.* South Holland, Illinois: Goodheart-Willcox Co., 1969.

C. *A Power Primer*. Detroit, Michigan: General Motors, 1955.

BASIC ENGINE PRINCIPLES
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Force--Any agent that produces or tends to produce motion

B. Work--Results of force overcoming a resistance over a definite distance

C. Energy--Ability to do work

D. Potential energy--Stored energy

E. Kinetic energy--Energy in motion

F. Power--Rate at which work is done

G. Horsepower--Measurement of work accomplished in a given period of time

H. Torque--Measurement of turning effort

I. Friction--Resistance to relative motion between two bodies in contact

J. PSI--Abbreviation for pounds per square inch; most common unit for measuring pressure

(NOTE: The metric equivalent to psi is kilogram per square centimeter [kg/cm^2].)

K. Mechanical power--Transmission and control of motion through the use of gears, pulleys, shafts, and other mechanical devices

L. Reciprocating motion--Back-and-forth motion

M. Cycle--Series of events or operations that happen regularly and lead back to the starting point

N. Control--To exercise restraining or directing influence over working forces

O. Transmission--Relaying of a working force

P. TDC--Top dead center

Q. BDC--Bottom dead center

INFORMATION SHEET

R. Stroke--Distance the piston moves when traveling from TDC to BDC

S. Bore--Diameter of the cylinder

T. Displacement--Total volume of air-fuel compressed by the piston in traveling from BDC to TDC

U. CID--Cubic inch displacement

(NOTE: Metric measurement for displacement is in cubic centimeters or liters.)

V. Volume--Total space between the piston at BDC and the cylinder head

W. Clearance volume--Total space between the piston at TDC and the cylinder head

X. Compression ratio--Ratio of whole cylinder volume to clearance volume

Example: If cylinder volume at TDC is 45 cubic inches and clearance volume is 5 cubic inches, then the compression ratio is $45 \div 5 = 9$ or 9:1 ratio

Y. Combustion--Action or operation of burning

Z. Volumetric efficiency--Comparison between the actual volume of air-fuel mixture drawn in on the intake stroke and the volume that would be drawn in if the cylinder were to be completely filled

II. Characteristics of energy

A. Is ever present

B. Cannot be created or destroyed

C. Can only be changed from one kind to another

III. Types of energy

A. Light

(NOTE: Light energy promotes growth in plants and makes our surroundings visible.)

B. Heat

(NOTE: Heat energy cooks food, develops mechanical energy to power automobiles, and warms homes.)

INFORMATION SHEET

C. Chemical

(NOTE: Chemical energy is the energy of life.)

D. Electrical

(NOTE: Electrical energy is the most flexible and is best known for lighting lights, running motors, and providing communications.)

E. Nuclear

(NOTE: Nuclear energy, also known as atomic energy, is produced through rearrangement of atoms.)

F. Mechanical

(NOTE: Mechanical energy is contained in every moving object; it is the energy involved in motion.)

IV. Forms of available energy

A. Potential

(NOTE: Potential energy is stored energy.)

Examples: Fuel, stretched spring wood, coal

B. Kinetic

(NOTE: Kinetic energy is energy in motion.)

Examples: Gasoline burning, wind, water

V. Types of motion (Transparency 1)

A. Reciprocating

B. Rotary

C. Linear

VI. Simple machines

(NOTE: All of the complicated mechanisms used in the operation, manufacture, and repair of an automobile are combinations of six simple machines.)

A. Lever (Transparency 2)

B. Wheel and axle (Transparency 3)

INFORMATION SHEET

- C. Pulley (Transparency 4)
- D. Inclined plane (Transparency 5)
- E. Screw (Transparency 6)
- F. Wedge (Transparency 7)

VII. Uses of simple machines

- A. Increase force
- B. Change direction
- C. Change speed

VIII. Calculating work

Work = Force x Distance

(NOTE: Force must be used to measure work for all movement except lifting. Work is measured in foot pounds.)

Example: How much work is accomplished if it takes 80 pounds of force to move a 300-pound box 50 feet?

W = F x D
W = 80 x 50
W = 4000 foot pounds

IX. Calculating horsepower

$$\text{Horsepower} = \frac{\text{Force x Distance}}{\text{Time (sec) x 550}} \quad \text{or} \quad \frac{\text{Weight x Distance}}{\text{Time (sec) x 550}}$$

(NOTE: One horsepower is 550 foot pounds of work done in one second. Force must be used instead of weight in all situations except lifting.)

Example: A 180-pound man climbs a 10-foot flight of stairs in 5 seconds. How much horsepower does he develop?

$$HP = \frac{W \times D}{\text{Time (sec)} \times 550}$$

$$HP = \frac{180 \times 10}{5 \times 550}$$

$$HP = \frac{1800}{2750}$$

HP = .65 horsepower

INFORMATION SHEET

X. Formula for torque

Torque = Force x Radius

(NOTE: Unit of measurement is pound feet measured as a force applied to a radius.)

Example: If 25 pounds of force is applied to a wrench 2 feet long, what is the torque?

T = F x R
T = 25 x 2
T = 50 pound feet

XI. Characteristic of heat engines--Converts heat energy into usable power in the form of motion

XII. Types of heat engines

A. External combustion--Fuel produces heat energy outside the engine and is transmitted to the engine by water or other means to power the engine which converts heat energy to motion

B. Internal combustion--Fuel is burned inside the engine to produce heat energy which the engine converts to motion

Examples: Gasoline, diesel

XIII. Parts of basic internal combustion engine (Transparency 8)

A. Cylinder--Hollow tube closed at one end

B. Piston--Cylindrical object which slides in the tube, fitting tightly to seal other end of tube

C. Connecting rod--Straight rod with one end connected to a pivot in the piston so lower end can swing with the rotation of the crankshaft

D. Crankshaft--Main shaft of an engine which in conjunction with connecting rods changes reciprocating motion of pistons into rotary motion

(NOTE: The lower end of the connecting rod is connected to offset center portion of crankshaft and must follow the same circular path as shaft.)

E. Valve--Movable plug to open and close the cylinder in order to let in air-fuel mixture and to remove the burned fuel from the cylinder

F. Camshaft--Shaft on which lobes (humps) and bearing journals are located; usually used to open the valves

INFORMATION SHEET

XIV. Process for converting chemical energy into rotary motion (Transparency 9)

A. Gasoline and air are introduced into the upper end of the cylinder

B. Air-fuel mixture is ignited and burned, producing heat energy

C. Heat energy causes the cylinder gases to expand

D. Expansion of the burning gases pushes piston down the cylinder

E. Downward motion of piston transmits force to the crankshaft through the connecting rod to produce rotary motion

(NOTE: Rotary motion is a result of the turning crankshaft.)

XV. Operation of four-stroke cycle engine (Transparency 10)

(NOTE: *Four-stroke* refers to the number of times the piston moves up and down in the cylinder to complete one cycle of operation.)

A. Intake stroke

1. Cycle starts with piston at topmost position in cylinder (TDC) with intake valve open and exhaust valve closed

2. As the piston moves down the cylinder, it draws air-fuel mixture into the cylinder from the carburetor

3. When the piston reaches the bottom of the cylinder (BDC), the intake valve closes

(NOTE: This completes the intake stroke.)

B. Compression stroke

1. Air-fuel mixture is compressed tightly as the piston moves up the cylinder

2. Compression of the fuel creates heat which prepares the fuel for instant ignition

C. Power stroke

1. As the piston reaches the top of the cylinder on compression stroke, a spark from the ignition system ignites the air-fuel mixture

2. The burning gases expand very rapidly and force the piston down the cylinder

INFORMATION SHEET

D. Exhaust stroke

1. As the piston reaches the bottom of the cylinder on power stroke, the exhaust valve opens

2. The piston travels up the cylinder, forcing the burned gases out of the cylinder into the exhaust manifold

(NOTE: The complete cycle takes two rotations of the crankshaft or 720 degrees of rotation.)

XVI. Valve timing and overlap (Transparency 11)

(NOTE: Valve angles given below are approximated; the actual angles will vary widely depending upon engine design.)

A. Intake valve--Opens approximately 15 degrees before the intake stroke begins and remains open through intake stroke and 20 degrees into compression stroke

(NOTE: The intake valve is open approximately 235 degrees of the 720 degree cycle.)

B. Exhaust valve--Opens approximately 40 degrees before the exhaust stroke begins and remains open through exhaust stroke and 20 degrees into the intake stroke

(NOTE: The exhaust valve is open approximately 235 degrees of the 720 degree cycle.)

C. Valve overlap--Both intake and exhaust valves are partially open; the intake valve is starting to open while the exhaust valve is not yet closed

XVII. Operation of two-stroke cycle engine (Transparency 12)

(NOTE: The two-stroke cycle is best explained by starting with the piston at the bottom of the cylinder.)

A. Air-fuel mixture is introduced into the cylinder when piston is at the bottom

(NOTE: Fuel is pressured into cylinder by a blower or by crankcase pressure.)

B. Piston moves up the cylinder, compressing the mixture

C. Air-fuel mixture is ignited as piston reaches the TDC

(NOTE: The crankshaft has moved 1/2 revolution, 180 degrees.)

INFORMATION SHEET

D. Expanding gases push the piston down the cylinder forcing the crankshaft to rotate

E. As piston reaches the bottom of the cylinder again, burned gases are allowed to escape through one side of the cylinder or exhaust valve as a fresh charge of fuel and air is introduced in the other side

(NOTE: The crankshaft has now rotated one complete revolution, 360 degrees.)

XVIII. Formula for cubic inch displacement (Transparency 13)

$$\text{Cubic inch displacement} = \frac{\pi \times \text{Bore}^2 \times \text{Stroke}}{4} \times \text{Number of cylinders}$$

Example: An 8-cylinder engine with a 4" bore and 3 1/2" stroke has how much displacement?

$$\text{CID} = \frac{(3.1416) \times \text{Bore}^2\ (4^2) \times \text{Stroke}\ (3.5)}{4} \times \text{No. of cylinders (8)}$$

$$\text{CID} = \frac{3.1416 \times 4^2 \times 3.5}{4} \times 8$$

$$\text{CID} = 43.98 \times 8$$

$$\text{CID} = 351.84 \text{ cubic inch displacement}$$

(NOTE: One liter is equal to 61.02 cubic inches.)

XIX. Results of increasing compression ratio (Transparency 14)

A. Power increases as the compression ratio increases

B. Fuel economy increases as compression ratio increases

(NOTE: The highest ratio that is practical for a gasoline engine is in the range of 10:1 to 12:1.)

C. Higher octane fuel is required as the compression ratio is increased to prevent engine knock due to detonation

D. Higher compression ratios produce more exhaust gas pollutants

XX. Components of an automobile engine (Transparency 15)

A. Cylinder block

B. Cylinder

C. Piston

INFORMATION SHEET

D. Connecting rod
E. Crankshaft
F. Crankshaft gear
G. Camshaft
H. Camshaft gear
I. Camshaft gear cover
J. Valve lifter
K. Push rod
L. Rocker arm
M. Valve
N. Valve cover
O. Cylinder head
P. Oil pan
Q. Oil pump
R. Flywheel
S. Vibration dampener
T. Water pump
U. Exhaust manifold
V. Intake manifold
W. Carburetor
X. Fuel pump
Y. Air filter
Z. Distributor
AA. Oil filter

INFORMATION SHEET

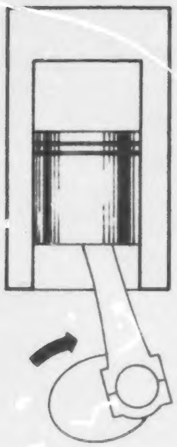
XXI. Gasoline and diesel engines

- A. Gasoline engines
  - 1. Lower compression ratio
  - 2. Fuel mixture ignited by electrical spark
  - 3. Highly volatile gasoline used for fuel
- B. Diesel engines
  - 1. Very high compression
  - 2. Fuel mixture ignited by heat created by extremely high compression
  - 3. Low volatile oil used for fuel

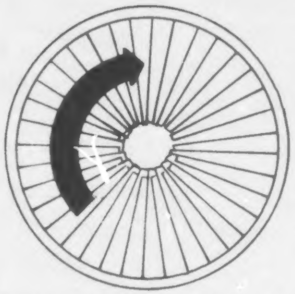
XXII. Purposes of a heavy flywheel

- A. Smooth out surges of the power strokes
- B. Maintain crankshaft motion between power strokes
- C. Develop kinetic energy when spinning
- D. Provide gear teeth on outer rim for starting motor operation

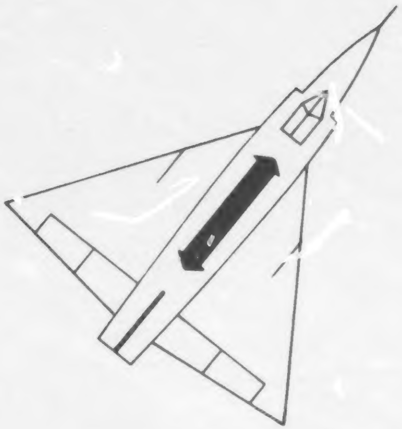
Types of Motion



Reciprocating Input Motion
From a Piston

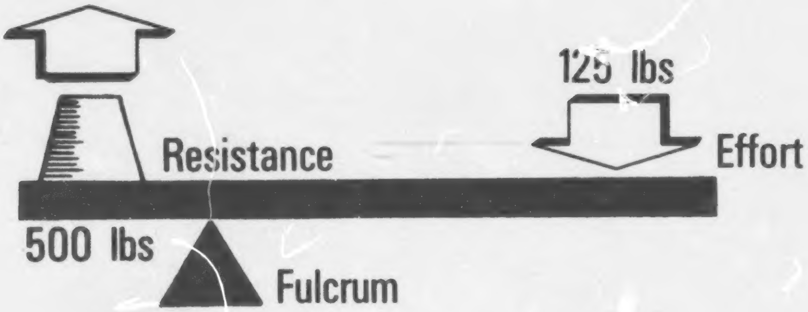


Rotary Input Motion
from a Turbine

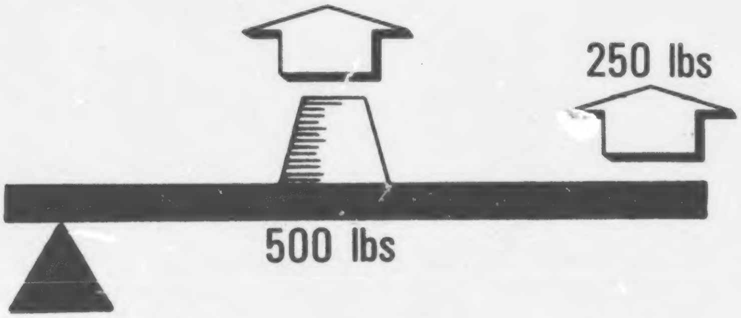


Linear Input Motion
from a Jet

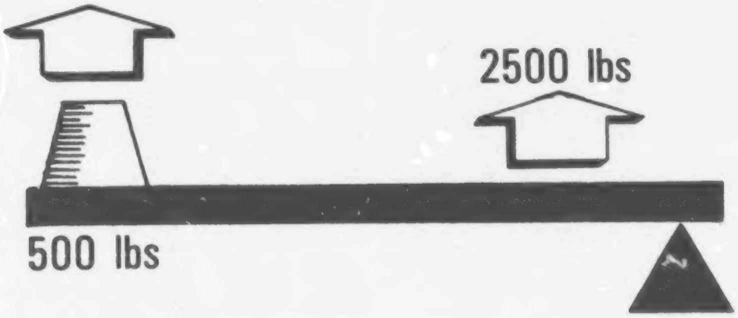
The Principle of the Lever


125 lbs
Resistance
Effort
500 lbs
Fulcrum

First Class

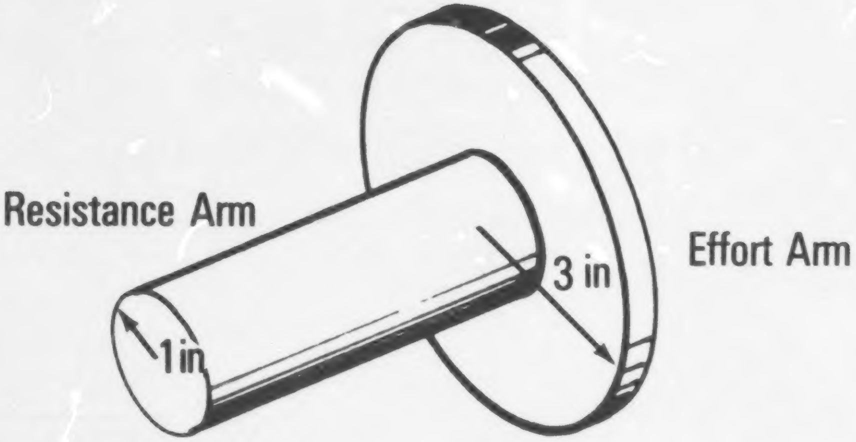

250 lbs
500 lbs

Second Class


2500 lbs
500 lbs

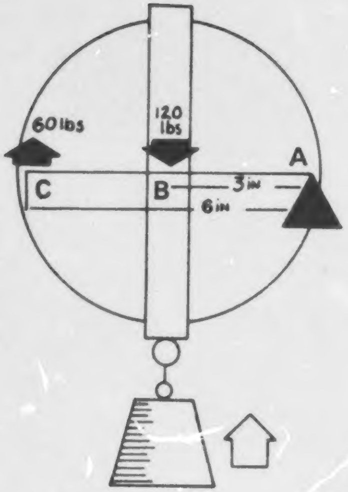
Third Class

The Principle of the Wheel and Axle

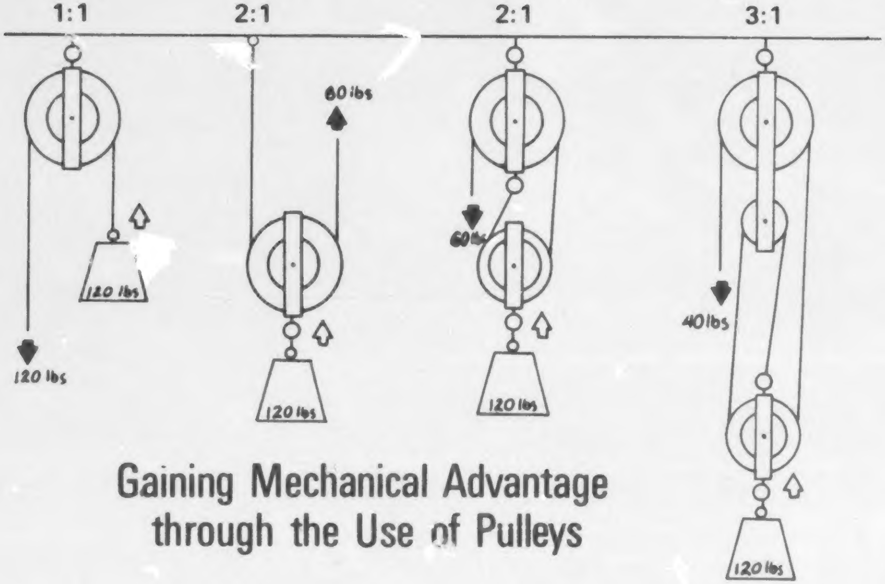

Resistance Arm
Effort Arm
3 in
1 in

The Mechanical Advantage of the Wheel and Axle is the Ratio between the Two Lever Arms, 3 to 1

The Principle of the Pulley

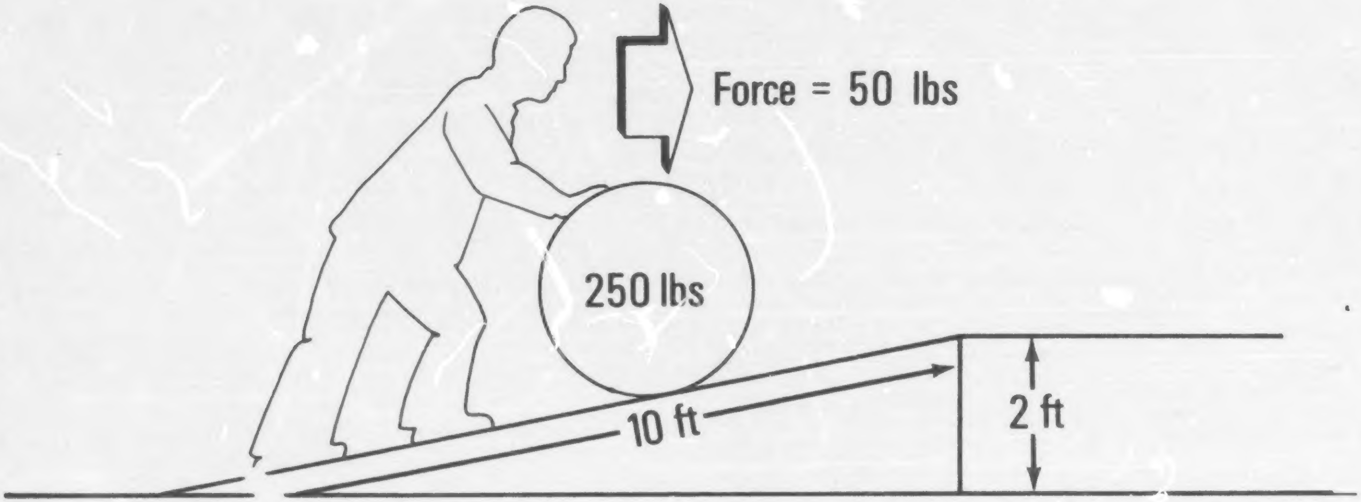

60 lbs
120 lbs
A
C
B
3 in
6 in

The Pulley Operates as a Second Class Lever

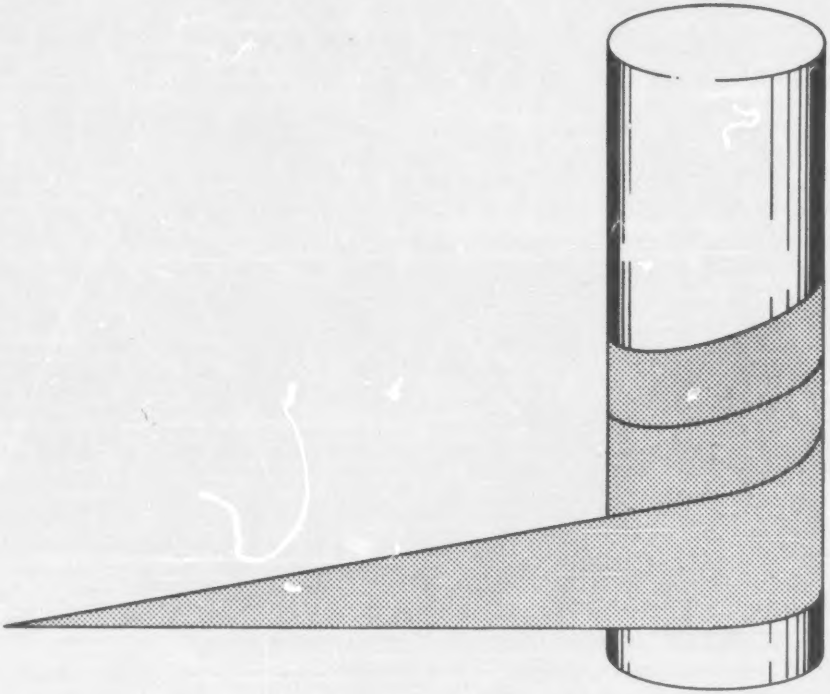

1:1
2:1
2:1
3:1
120 lbs
120 lbs
60 lbs
120 lbs
60 lbs
120 lbs
40 lbs
120 lbs

Gaining Mechanical Advantage through the Use of Pulleys

The Principle of the Inclined Plane

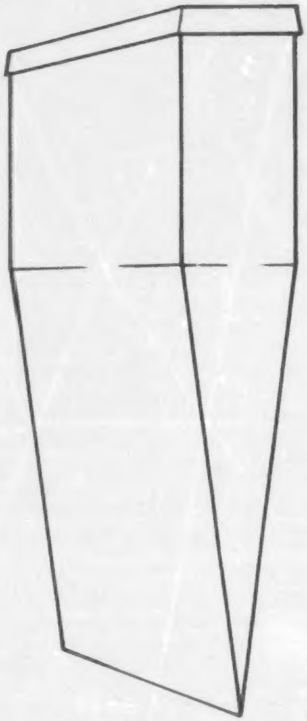

Force = 50 lbs
250 lbs
10 ft
2 ft

The Principal of the Screw

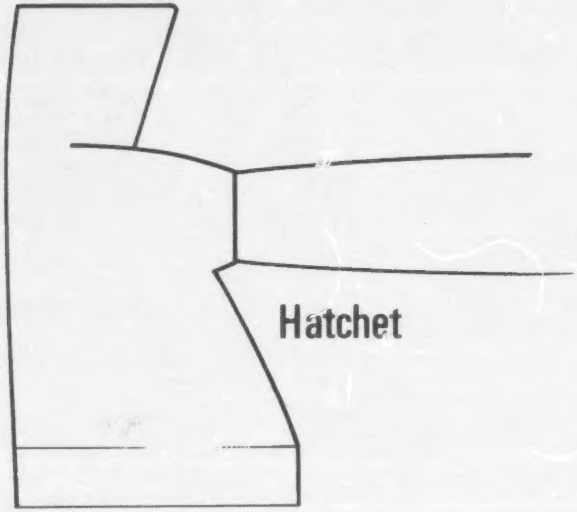


The Screw Is Illustrated by an Inclined Plane Wrapped Around a Shaft

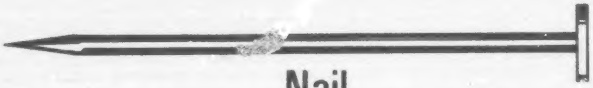
The Principle of the Wedge



Splitting Wedge



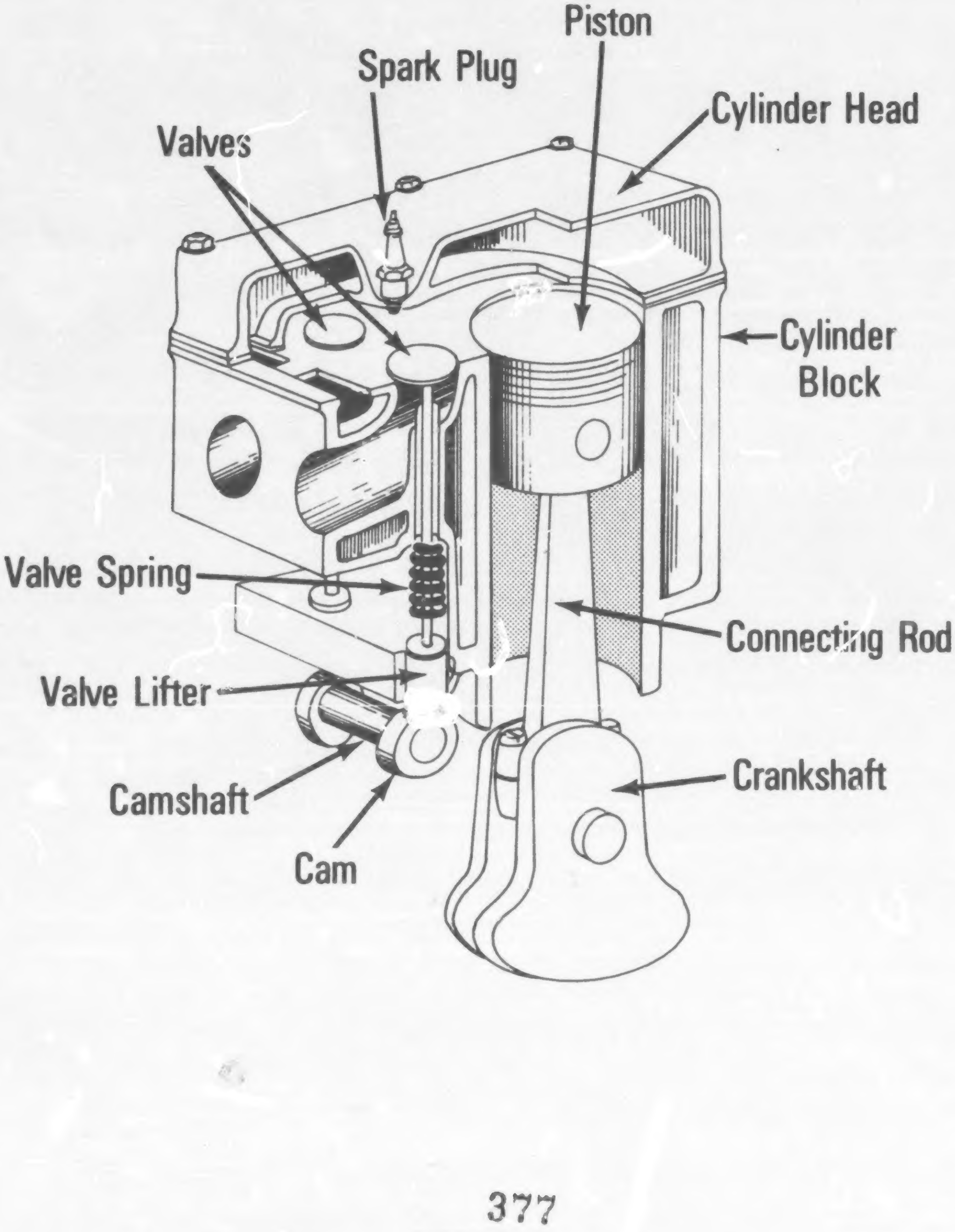
Hatchet



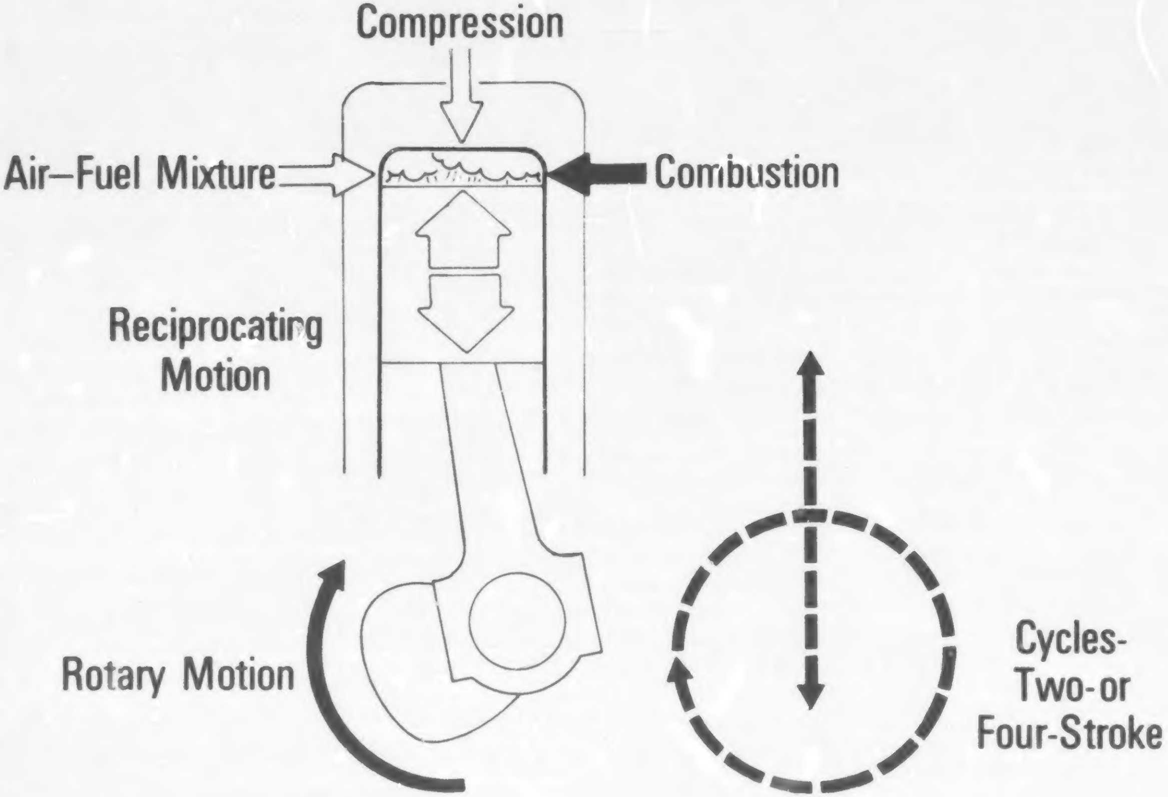
Nail

AM I - 27-C

Basic Internal Combustion Engine Parts


Piston
Spark Plug
Cylinder Head
Valves
Cylinder Block
Valve Spring
Connecting Rod
Valve Lifter
Crankshaft
Camshaft
Cam

Chemical Energy to Rotary Motion



Compression

Air–Fuel Mixture

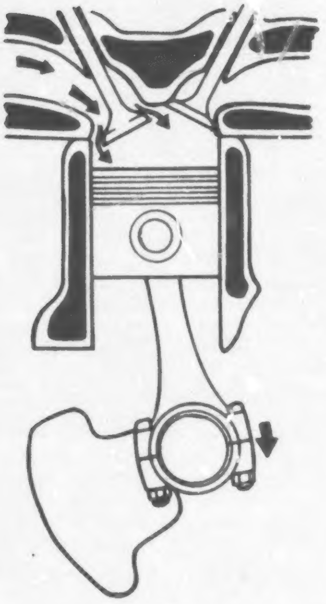
Combustion

Reciprocating Motion

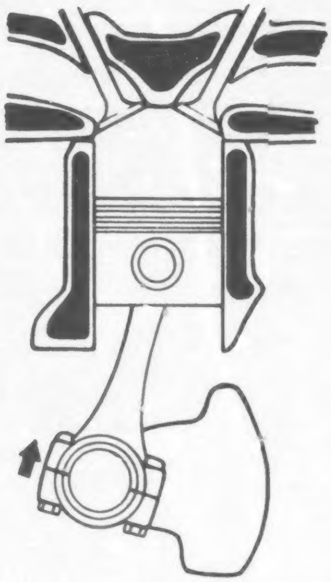
Rotary Motion

Cycles-
Two-or
Four-Stroke

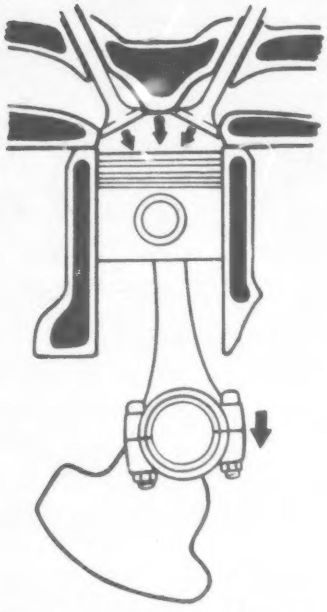
Four-Stroke Cycle



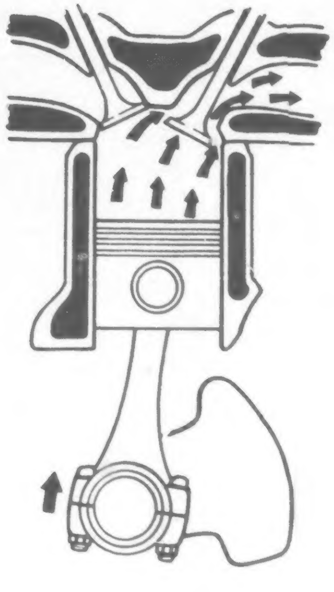
Piston Intake Stroke



Piston Compression Stroke

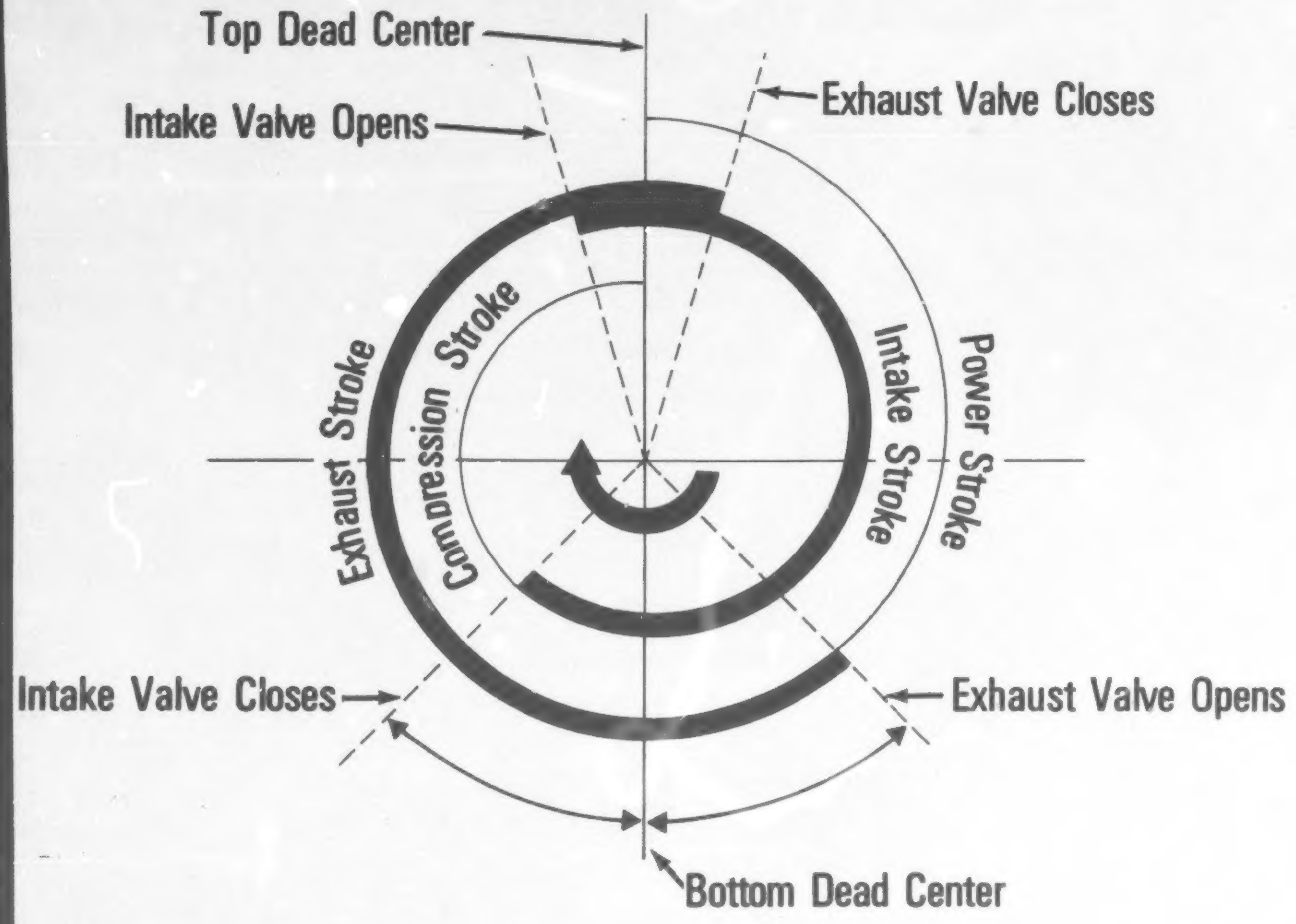


Piston Power Stroke

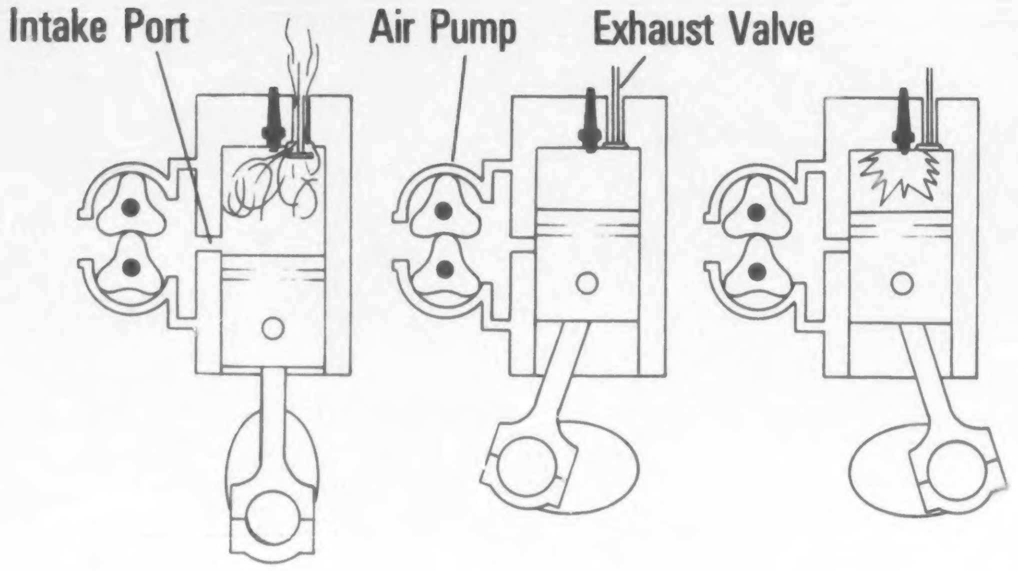


Piston Exhaust Stroke

Valve Timing and Overlap


Top Dead Center
Intake Valve Opens
Exhaust Valve Closes
Exhaust Stroke
Compression Stroke
Intake Stroke
Power Stroke
Intake Valve Closes
Exhaust Valve Opens
Bottom Dead Center

Two-Stroke Cycle

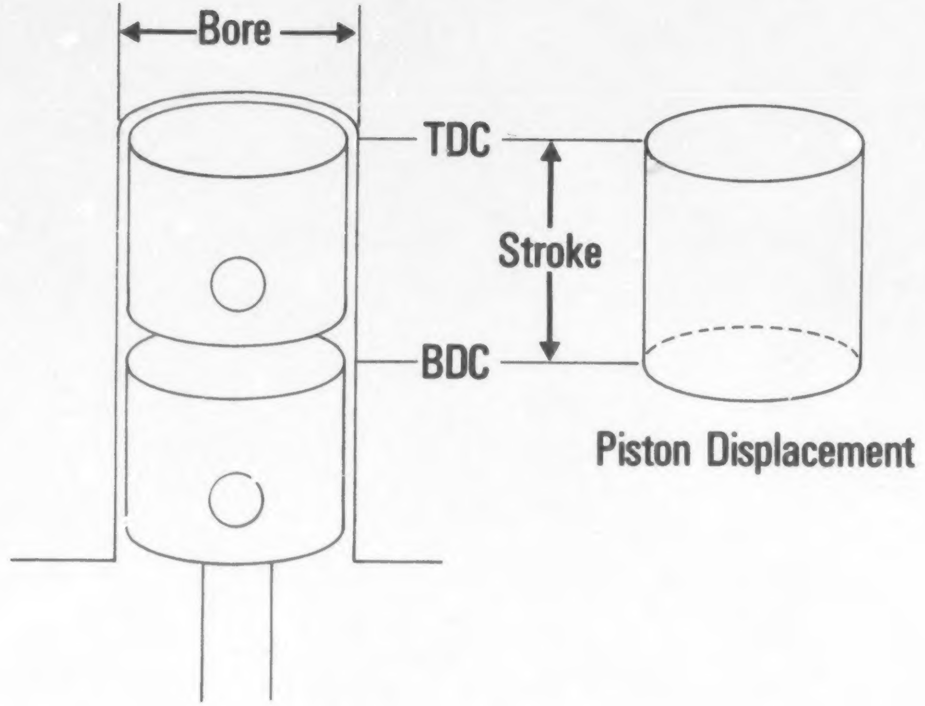

Intake Port
Air Pump
Exhaust Valve

BETWEEN STROKES
INTAKE AND EXHAUST

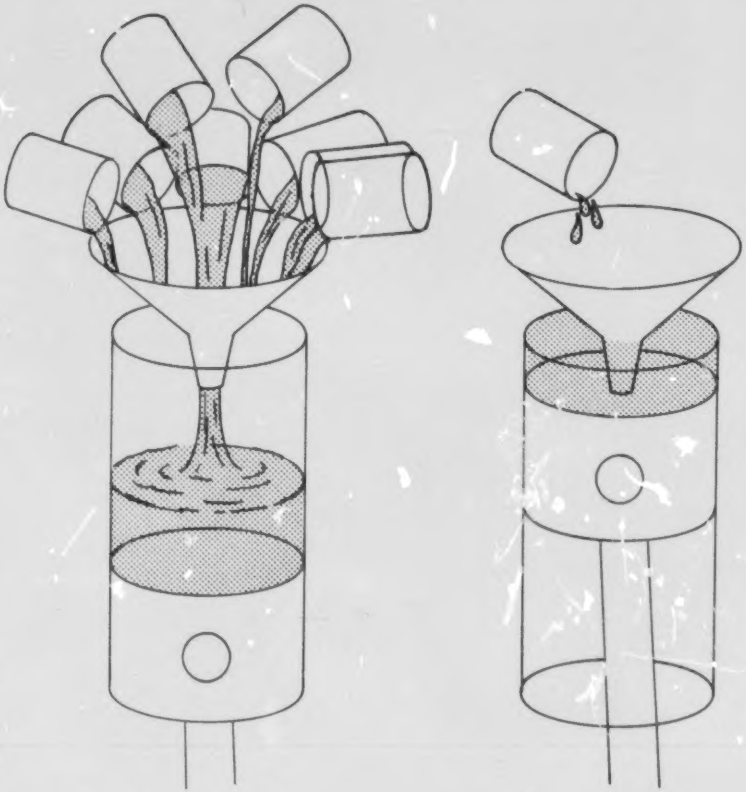
STROKE ONE
COMPRESSION

STROKE TWO
POWER

Cubic Inch Displacement


Bore
TDC
Stroke
BDC
Piston Displacement

Compression Ratio

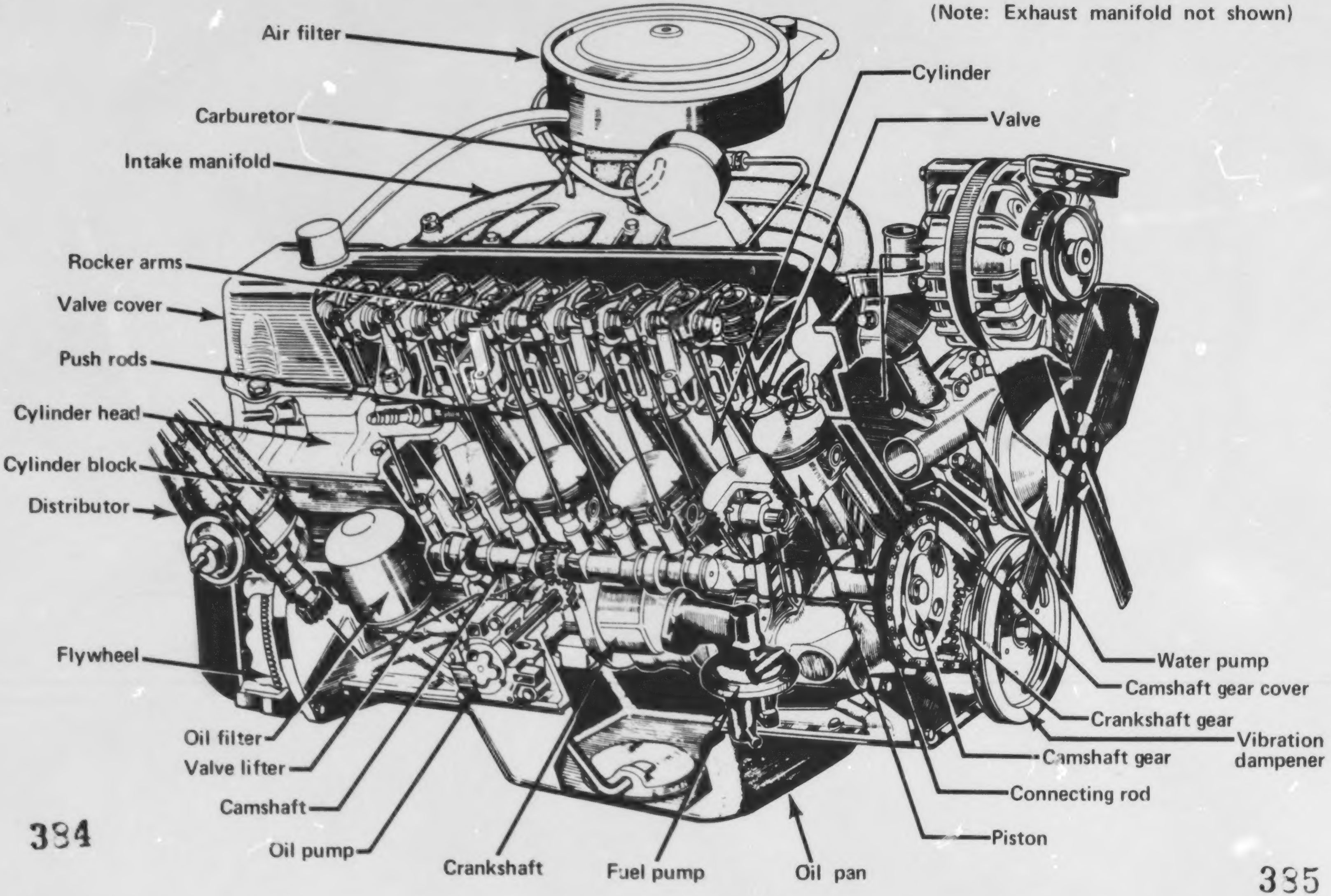


8 with Piston
at the Bottom

1 with Piston
at the Top

AM I - 41-C

Components of an Automobile Engine


Air filter
Carburetor
Intake manifold
Rocker arms
Valve cover
Push rods
Cylinder head
Cylinder block
Distributor
Flywheel
Oil filter
Valve lifter
Camshaft
Oil pump
Crankshaft
Fuel pump
Oil pan
Piston
Connecting rod
Camshaft gear
Vibration dampener
Crankshaft gear
Camshaft gear cover
Water pump
Valve
Cylinder

(Note: Exhaust manifold not shown)

BASIC ENGINE PRINCIPLES
UNIT I

ASSIGNMENT SHEET #1--CALCULATE WORK

Calculate the following problems using the formula for work.

Work = Force x Distance

1. Two men push a 300-pound weight a distance of 50 feet along a warehouse floor. The force necessary to slide the weight is 110 pounds. How much work is accomplished?

2. How much work is accomplished if it takes 92 pounds of force to move a 400-pound object 44 feet?

3. It takes 49 pounds of force to move a 92-pound box 60 feet across the floor. How much work is accomplished?

BASIC ENGINE PRINCIPLES
UNIT I

ASSIGNMENT SHEET #2--CALCULATE HORSEPOWER

Calculate the following problems using the formula for horsepower.

$$HP = \frac{F \times D}{\text{Time (sec)} \times 550}$$

1. A 200-pound man climbs a 40-foot flight of stairs in 20 seconds. How much horsepower does he develop performing this feat?

2. A 1000-pound weight is moved a distance of 60 feet across the floor. The force necessary to move the weight is 200 pounds and the time required to accomplish this is one minute. How much horsepower is required to perform this task?

3. A man pushes a 400-pound weight a distance of 10 feet along the loading dock. The force required to move the weight is 500 pounds. The task is completed in 5 seconds. How much horsepower is produced?

BASIC ENGINE PRINCIPLES
UNIT I

ASSIGNMENT SHEET #3--CALCULATE TORQUE

Calculate the following problems using the formula for torque.

Torque = Force x Radius

1. If a mechanic uses a wrench 1.5 feet long to apply a 40-pound force to a bolt, what is the torque on the bolt?

2. If 15 pounds of force is applied to a wrench 6 inches long, how much is the torque?

3. What is the torque if a force of 40 pounds is applied to a wrench 2 feet long?

BASIC ENGINE PRINCIPLES
UNIT I

ASSIGNMENT SHEET #4--CALCULATE CUBIC INCH DISPLACEMENT

Calculate the following problems using the formula for cubic inch displacement. Round answers to nearest whole number.

$$\text{CID} = \frac{\pi \times \text{Bore}^2 \times \text{Stroke}}{4} \times \text{Number of cylinders}$$

1. What is the CID of a cylinder with a 2-inch bore and a 3-inch stroke?

2. What is the CID of an 8-cylinder engine with a 4.125-inch bore and a 3.75-inch stroke?

ASSIGNMENT SHEET #4

3. Compute the CID of a 4-cylinder engine with a 3-inch bore and a 4.5-inch stroke.

4. What is the CID of a 6-cylinder engine with a 3.40-inch bore and a 4.125-inch stroke?

5. What is the CID on an 8-cylinder engine with a 4.000-inch bore and a 3.58-inch stroke?

BASIC ENGINE PRINCIPLES
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. $W = F \times D$
   $W = 110 \times 50$
   $W = 5500$ foot pounds

2. $W = F \times D$
   $W = 92 \times 44$
   $W = 4048$ foot pounds

3. $W = F \times D$
   $W = 49 \times 60$
   $W = 2940$ foot pounds

Assignment Sheet #2

1. $HP = \frac{F \times D}{\text{Time (sec)} \times 550}$
   $HP = \frac{200 \times 40}{20 \times 550}$
   $HP = \frac{8000}{11000}$
   $HP = .727$ or approx. 7/10 horsepower

2. $HP = \frac{F \times D}{\text{Time (sec)} \times 550}$
   $HP = \frac{200 \times 60}{60 \times 550}$
   $HP = \frac{12000}{33{,}000}$
   $HP = .364$ horsepower

3. $HP = \frac{F \times D}{\text{Time (sec)} \times 550}$
   $HP = \frac{500 \times 10}{5 \times 550}$
   $HP = \frac{5000}{2750}$
   $HP = 1.82$ horsepower

Assignment Sheet #3

1. $T = F \times R$
   $T = 40 \times 1.5$
   $T = 60$ pound feet

Assignment Sheet #3 (continued)

2. $T = F \times R$
$T = 15 \times .5$
$T = 7.5$ pound feet

3. $T = F \times R$
$T = 40 \times 2$
$T = 80$ pound feet

Assignment Sheet #4

1. $$\text{CID} = \frac{3.1416 \times 2^2 \times 3}{4} \times 1$$
$$\text{CID} = \frac{3.1416 \times 4 \times 3}{4} \times 1$$
$$\text{CID} = \frac{37.6992}{4} \times 1$$
$$\text{CID} = 9.4248 \text{ or } 9$$

2. $$\text{CID} = \frac{3.1416 \times 4.125^2 \times 3.75}{4} \times 8$$
$$\text{CID} = \frac{3.1416 \times 17.0156 \times 3.75}{4} \times 8$$
$$\text{CID} = \frac{200.4611}{4} \times 8$$
$$\text{CID} = 50.1153 \times 8$$
$$\text{CID} = 400.9221 \text{ or } 401$$

3. $$\text{CID} = \frac{3.1416 \times 3^2 \times 4.5}{4} \times 4$$
$$\text{CID} = \frac{3.1416 \times 9 \times 4.5}{4} \times 4$$
$$\text{CID} = \frac{127.2348}{4} \times 4$$
$$\text{CID} = 31.8087 \times 4$$
$$\text{CID} = 127.2348 \text{ or } 127$$

Assignment Sheet #4 (continued)

4. $$\text{CID} = \frac{3.1416 \times 3.40^2 \times 4.125}{4} \times 6$$

$$\text{CID} = \frac{3.1416 \times 11.56 \times 4.125}{4} \times 6$$

$$\text{CID} = \frac{149.8071}{4} \times 6$$

$$\text{CID} = 37.4518 \times 6$$

$$\text{CID} = 224.7108 \text{ or } 225$$

5. $$\text{CID} = \frac{3.1416 \times 4.000^2 \times 3.58}{4} \times 8$$

$$\text{CID} = \frac{3.1416 \times 16 \times 3.58}{4} \times 8$$

$$\text{CID} = \frac{179.9508}{4} \times 8$$

$$\text{CID} = 44.9877 \times 8$$

$$\text{CID} = 359.9017 \text{ or } 360$$

BASIC ENGINE PRINCIPLES
UNIT I

TEST

1. Match the terms on the right with the correct definitions. (Terms and definitions are continued on the following page.)

_____a. Any agent that produces or tends to produce motion

_____b. Rate at which work is done

_____c. Ability to do work

_____d. Stored energy

_____e. Measurement of turning effort

_____f. Transmission and control of motion through the use of gears, pulleys, shafts, and other mechanical devices

_____g. Bottom dead center

_____h. To exercise restraining or directing influence over working forces

_____i. Back-and-forth motion

_____j. Energy in motion

_____k. Relaying of a working force

_____l. Measurement of work accomplished in a given period of time

_____m. Abbreviation for pounds per square inch; most common unit for measuring pressure

_____n. Series of events or operations that happen regularly and lead back to the starting point

_____o. Resistance to relative motion between two bodies in contact

1. Energy
2. Work
3. Force
4. Friction
5. Power
6. Kinetic energy
7. Torque
8. Horsepower
9. Potential energy
10. PSI
11. Cycle
12. TDC
13. Mechanical power
14. Transmission
15. Reciprocating motion
16. BDC
17. Control

______p. Results of force overcoming a resistance over a definite distance

______q. Top dead center

______r. Total volume of air-fuel compressed by the piston in traveling from BDC to TDC

______s. Cubic inch displacement

______t. Ratio of whole cylinder volume to clearance volume

______u. Action or operation of burning

______v. Distance the piston moves when traveling from TDC to BDC

______w. Total space between the piston at BDC and the cylinder head

______x. Diameter of the cylinder

______y. Total space between the piston at TDC and the cylinder head

______z. Comparison between the actual volume of air-fuel mixture drawn in on the intake stroke and the volume that would be drawn in if the cylinder were to be completely filled

18. Volumetric efficiency
19. Volume
20. Stroke
21. Clearance volume
22. Combustion
23. Compression ratio
24. CID
25. Displacement
26. Bore

2. Discuss the characteristics of energy.

3. List six types of energy.

a.

b.

c.

d.

e.

f.

4. List two forms of available energy.

   a.

   b.

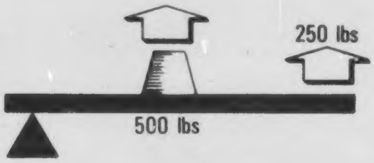
5. List three types of motion.

   a.

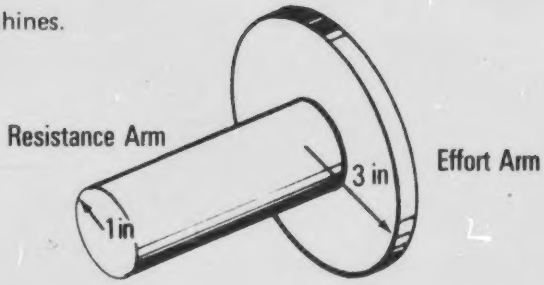
   b.

   c.

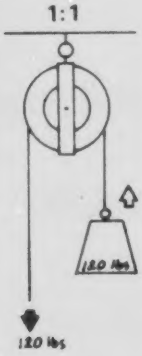
6. Identify the following simple machines.


250 lbs
500 lbs

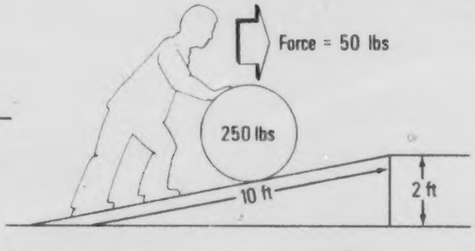
a.


Resistance Arm
3 in
Effort Arm
1 in

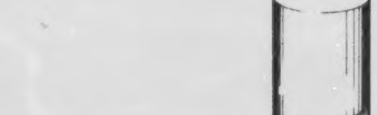
b.


1:1
120 lbs
120 lbs

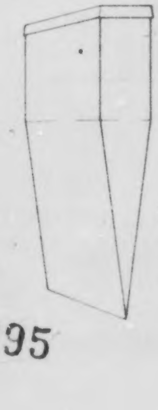
c.


Force = 50 lbs
250 lbs
10 ft
2 ft

d.



e.



f.

7. List three uses of simple machines.

   a.

   b.

   c.

8. Calculate the following problem using the formula for work.

   W = F x D

   A boy pushes a 200-pound box a distance of 20 feet along the floor. The force necessary to slide the box is 55 pounds. How much work is accomplished?

9. Calculate the following problem using the formula for horsepower.

   $$HP = \frac{F \times D}{\text{Time (sec)} \times 550}$$

   Using the problem above, how much horsepower is produced if it takes 20 seconds to slide the box along the floor?

10. Calculate the following problem using the formula for torque.

    T = F x R

    What is the torque if a force of 40 pounds is applied to a wrench 2 feet long?

11. Describe the characteristic of heat engines.

12. Distinguish between external and internal combustion engines by placing an "X" in front of the description of an internal combustion engine.

    ______a. Fuel is burned inside the engine to produce heat energy which the engine converts to motion

    ______b. Fuel produces heat energy outside the engine and is transmitted to the engine by water or other means to power the engine which converts heat energy to motion

13. Match the parts of a basic internal combustion engine to the correct descriptions.

    ______a. Hollow tube closed at one end

    ______b. Cylindrical object which slides in the tube, fitting tightly to seal other end of tube

    ______c. Straight rod with one end connected to a pivot in the piston so lower end can swing with the rotation of the crankshaft

    ______d. Main shaft of an engine which in conjunction with connecting rods changes reciprocating motion of pistons into rotary motion

    ______e. Movable plug to open and close the cylinder in order to let in air-fuel mixture and to remove the burned fuel from the cylinder

    ______f. Shaft on which lobes (humps) and bearing journals are located; usually used to open the valves

    1. Valve
    2. Crankshaft
    3. Piston
    4. Cylinder
    5. Connecting rod
    6. Camshaft

14. Describe the process by which an automobile engine converts chemical energy into rotary motion.

15. Discuss the operation of a four-stroke cycle engine.

16. Discuss specific valve timing and valve overlap.

    a. Intake valve

    b. Exhaust valve

    c. Valve overlap

17. Discuss the operation of the two-stroke cycle engine beginning with the piston positioned at the bottom of the cylinder.

18. State the formula for calculating engine cubic inch displacement.

CID =

19. Explain the results of increasing the compression ratio.

20. Identify the components of the automobile engine illustrated on the following page by placing the correct numbers in the blanks provided.

______a. Cylinder block

______b. Cylinder

______c. Piston

______d. Connecting rod

______e. Crankshaft

______f. Crankshaft gear

______g. Camshaft

______h. Camshaft gear

______i. Camshaft gear cover

______j. Valve lifter

______k. Push rods

______l. Rocker arms

______m. Valve

______n. Valve cover

______o. Cylinder head

______p. Oil pan

______q. Oil pump

______r. Flywheel

______s. Vibration dampener

______t. Water pump

______u. Intake manifold

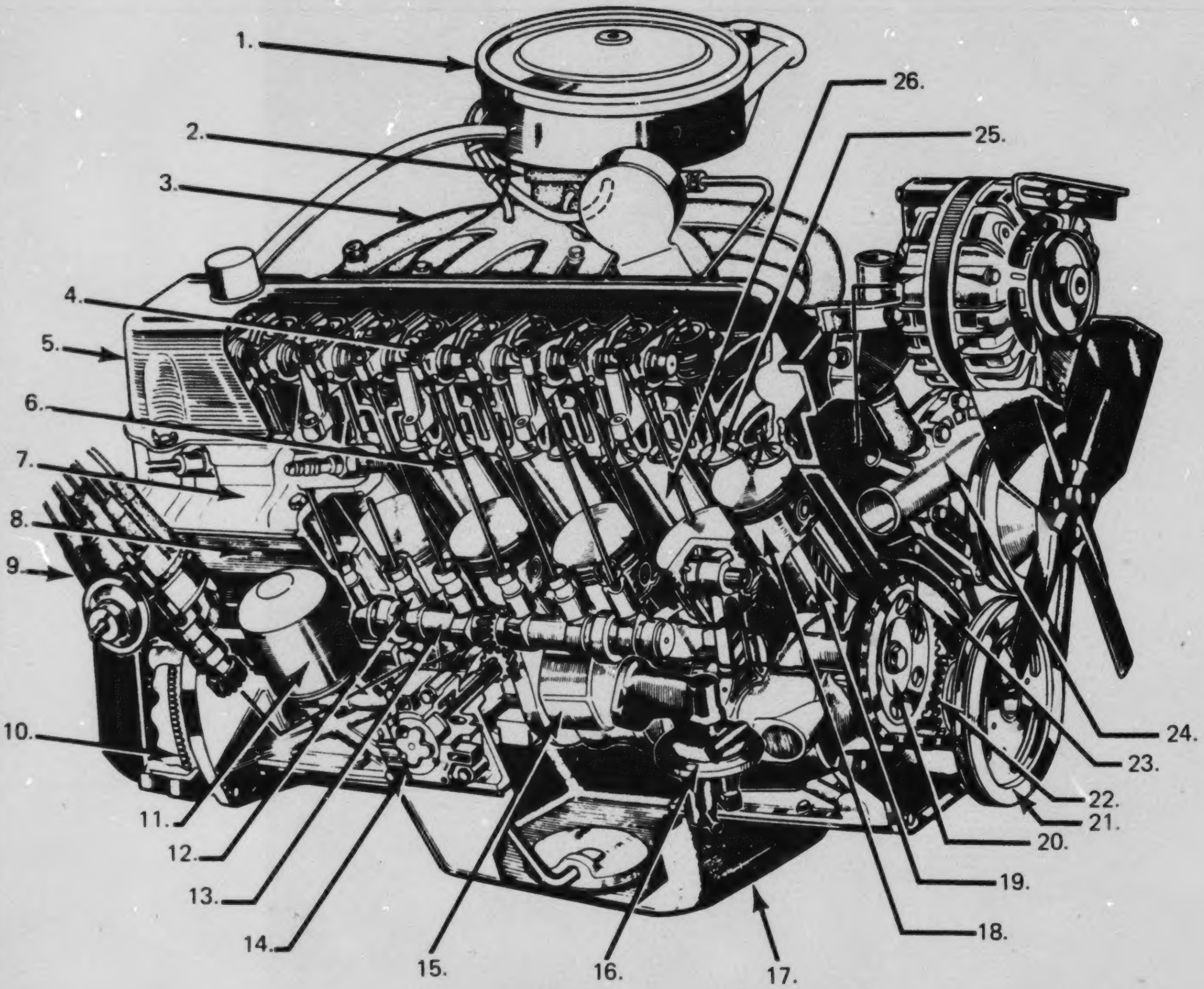
______v. Carburetor

______w. Fuel pump

______x. Air filter

______y. Distributor

______z. Oil filter


1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.
23.
24.
25.
26.

AM I- 65-C

21. Distinguish between gasoline and diesel engines by placing a "G" in front of the statements concerning gasoline engines and a "D" in front of those relating to diesel engines.

______a. Fuel mixture ignited by electrical spark

______b. Fuel mixture ignited by heat created by extremely high compression

______c. Low volatile oil used for fuel

______d. Lower compression ratio

______e. Highly volatile gasoline used for fuel

______f. Very high compression

22. Discuss the purposes of a heavy flywheel.

BASIC ENGINE PRINCIPLES
UNIT I

ANSWERS TO TEST

1. a. 3
   b. 5
   c. 1
   d. 9
   e. 7
   f. 13
   g. 16
   h. 17
   i. 15
   j. 6
   k. 14
   l. 8
   m. 10
   n. 11
   o. 4
   p. 2
   q. 12
   r. 25
   s. 24
   t. 23
   u. 22
   v. 20
   w. 19
   x. 26
   y. 21
   z. 18

2. Discussion should include:
   a. Is ever present
   b. Cannot be created or destroyed
   c. Can only be changed from one kind to another

3. a. Light
   b. Heat
   c. Chemical
   d. Electrical
   e. Nuclear
   f. Mechanical

4. a. Potential
   b. Kinetic

5. a. Reciprocating
   b. Rotary
   c. Linear

6. a. Lever
   b. Wheel and axle
   c. Pulley
   d. Inclined plane
   e. Screw
   f. Wedge

7. a. Increase force
   b. Change direction
   c. Change speed

8. W = F x D
   W = 55 lbs x 20 ft
   W = 1100 foot pounds

9. $$HP = \frac{F \times D}{\text{Time (sec)} \times 550}$$
   $$HP = \frac{55 \times 20}{20 \times 550}$$
   $$HP = \frac{1100}{11000}$$
   $$HP = .10$$

10. T = F x R
    T = 40 x 2
    T = 80 pound feet

11. Description should include--Converts heat energy into usable power in the form of motion

12. a

13. a. 4
    b. 3
    c. 5
    d. 2
    e. 1
    f. 6

14. Description should include:
    a. Gasoline and air are introduced into the upper end of the cylinder
    b. Air-fuel mixture is ignited and burned, producing heat energy
    c. Heat energy causes the cylinder gases to expand

d. Expansion of the burning gases pushes piston down the cylinder

e. Downward motion of piston transmits force to the crankshaft through the connecting rod to produce rotary motion

15. Discussion should include:

    a. Intake stroke

        1. Cycle starts with piston at topmost position in cylinder (TDC) with intake valve open and exhaust valve closed

        2. As the piston moves down the cylinder, it draws air-fuel mixture into the cylinder from the carburetor

        3. When the piston reaches the bottom of the cylinder (BDC), the intake valve closes

    b. Compression stroke

        1. Air-fuel mixture is compressed tightly as the piston moves up the cylinder

        2. Compression of the fuel creates heat which prepares the fuel for instant ignition

    c. Power stroke

        1. As the piston reaches the top of the cylinder on compression stroke, a spark from the ignition system ignites the air-fuel mixture

        2. The burning gases expand very rapidly and force the piston down the cylinder

    d. Exhaust stroke

        1. As the piston reaches the bottom of the cylinder on power stroke, the exhaust valve opens

        2. The piston travels up the cylinder, forcing the burned gases out of the cylinder into the exhaust manifold

16. Discussion should include:

    a. Intake valve--Opens approximately 15 degrees before the intake stroke begins and remains open through intake stroke and 20 degrees into compression stroke

b. Exhaust valve--Opens approximately 40 degrees before the exhaust stroke begins and remains open through exhaust stroke and 20 degrees into the intake stroke

c. Valve overlap--Both intake and exhaust valves are partially open; the intake valve is starting to open while the exhaust valve is not yet closed

17. Discussion should include:

a. Air-fuel mixture is introduced into the cylinder when the piston is at the bottom

b. Piston moves up the cylinder, compressing the mixture

c. Air-fuel mixture is ignited as piston reaches the TDC

d. Expanding gases push the piston down the cylinder forcing the crankshaft to rotate

e. As piston reaches the bottom of the cylinder again, burned gases are allowed to escape through one side of the cylinder or exhaust valve as a fresh charge of fuel and air is introduced in the other side

18. $\text{CID} = \dfrac{\pi \times \text{Bore}^2 \times \text{Stroke}}{4} \times \text{Number of cylinders}$

19. Explanation should include:

a. Power increases as the compression ratio increases

b. Fuel economy increases as compression ratio increases

c. Higher octane fuel is required as the compression ratio is increased to prevent engine knock due to detonation

d. Higher compression ratios produce more exhaust gas pollutants

20.
a. 8
b. 26
c. 18
d. 19
e. 15
f. 22
g. 13
h. 20
i. 23
j. 12
k. 6
l. 4
m. 25
n. 5
o. 7
p. 17
q. 14
r. 10
s. 21
t. 24
u. 3
v. 2
w. 16
x. 1
y. 9
z. 11

21.	a.	G	d.	G
	b.	D	e.	G
	c.	D	f.	D

22. Discussion should include:

   a. Smooth out surges of the power strokes

   b. Maintain crankshaft motion between power strokes

   c. Develop kinetic energy when spinning

   d. Provide gear teeth on outer rim for starting motor operation

COOLING SYSTEM
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to describe the construction and operation of the cooling system. The student should demonstrate the ability to pressure test, inspect, and repair the cooling system. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Write the purpose of the cooling system.
2. Match terms associated with the cooling system to the correct definitions.
3. Distinguish between types of thermostats.
4. Describe the operation of the thermostat when the engine is cold and when the engine is at operating temperature.
5. List jobs that the cooling system must perform.
6. Distinguish between a downflow and a crossflow radiator.
7. Describe methods of cooling the internal combustion engine.
8. Identify types of radiator hoses.
9. Describe pressure cap operation when the cooling system is at normal temperature, very hot with built-up excess pressure, and during the cooling-off period.
10. Describe the operation of the variable-speed fan drive.
11. List reasons for using a permanent antifreeze solution in the cooling system at all times.
12. Describe the operation of a coolant recovery system.
13. Demonstrate the ability to:
    a. Remove, check, and replace a thermostat.
    b. Remove and replace a water pump.

COOLING SYSTEM
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Demonstrate and discuss procedures outlined in the job sheets.

  G. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Demonstrate the ability to accomplish the procedures outlined in the job sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Cooling System Components

    2. TM 2--Types of Thermostats

    3. TM 3--Thermostat Operation

    4. TM 4--Downflow and Crossflow Radiators
    5. TM 5--Types of Radiator Hoses
    6. TM 6--Pressure Cap Operation
    7. TM 7--Variable-speed Fan Drive
    8. TM 8--Coolant Recovery System

  D. Job sheets

    1. Job Sheet #1--Remove, Check, and Replace a Thermostat
    2. Job Sheet #2--Remove and Replace a Water Pump
    3. Job Sheet #3--Remove and Replace a Radiator
    4. Job Sheet #4--Pressure Test the Cooling System
    5. Job Sheet #5--Remove, Inspect, and Replace V-Belts
    6. Job Sheet #6--Test Antifreeze Solution

  E. Test

  F. Answers to test

II. References:

  A. Toboldt, William K., and Purvis, Jud. *Motor Services Automotive Encyclopedia.* Homewood, Illinois: Goodheart-Willcox Co., 1965.

  B. Stockel, Martin W. *Auto Service and Repair.* Homewood, Illinois: Goodheart-Willcox Co., 1969.

  C. Crouse, William H. *Automotive Mechanics.* 5th ed. New York: McGraw-Hill Book Co., 1965.

  D. Stockel, Martin W. *Auto Mechanics Fundamentals.* South Holland, Illinois: Goodheart-Willcox Co., 1969.

  E. Glenn, Harold I. *Auto Mechanics.* Peoria, Illinois: Charles A. Bennett Co., 1962.

COOLING SYSTEM
UNIT II

INFORMATION SHEET

I. Purpose of the cooling system--To keep the engine at its most efficient operating temperature during all engine speeds and driving conditions

II. Terms and definitions (Transparency 1)

  A. Water pump--Centrifugal pump mounted at the front of the cylinder block to circulate the coolant throughout the cooling system

  B. Water jacket--Passage through the block and cylinder head that allows the coolant to circulate around the cylinders, valves, and combustion chambers

  C. Radiator--Device for holding a considerable volume of coolant in close contact with a large amount of air so that heat may be transferred from the coolant to the air

  D. Radiator hose--Hose used to connect the radiator to the engine

  E. Fan--Device generally mounted on the water pump hub assembly used to pull a large volume of air through the openings in the radiator core

  F. Shroud--Funnel-like structure attached to the radiator and extending around and behind the fan; used to make the fan more effective in pulling air through the radiator

  G. Thermostat--Heat-controlled valve in the cooling system used to regulate the flow of coolant between the cylinder block and radiator

  H. Pressure cap--Cap which increases the pressure within the cooling system several pounds per square inch, allowing the coolant to circulate at higher temperatures without evaporation or surge loss

  I. V-belt--Belt turned by a pulley on the front of the crankshaft used to drive the water pump, fan, and other engine accessories

III. Types of thermostats (Transparency 2)

  A. Bellows--Contains a special liquid which heat causes to expand and open the thermostat valve

  B. Pellet--Contains copper-impregnated wax which heat causes to expand and open the thermostat valve

INFORMATION SHEET

IV. Thermostat operation (Transparency 3)

  A. Engine is cold--Thermostat shuts off flow of coolant from the engine to the radiator to allow quicker engine warm-up

  B. Engine is at operating temperature--Thermostat is open and allows coolant to circulate through the system

V. Jobs performed by the cooling system

  A. Remove surplus or unwanted heat

  B. Maintain an efficient temperature under all operating conditions

  C. Bring an engine up to operating temperature as soon after starting as possible

VI. Downflow and crossflow radiators (Transparency 4)

  A. Downflow radiator

    1. Tanks on top and bottom

    2. Flow of coolant from top to bottom

  B. Crossflow radiator

    1. Tanks on right and left sides

    2. Flow of coolant from side to side across radiator

  (NOTE: The crossflow radiator is used to allow a lower hood line.)

VII. Methods of cooling the internal combustion engine

  A. Liquid--Uses circulating coolant for engine heat removal

  B. Air--Uses a fan, cooling fins, and engine shrouding for heat removal

VIII. Types of radiator hoses (Transparency 5)

  A. Common

  (NOTE: This straight hose is made of rubber with one or two layers of fabric for strength. It will not withstand much bending without collapsing.)

INFORMATION SHEET

B. Molded or shaped

(NOTE: The hose is made of rubber with one or two layers of fabric for strength; all necessary bends are premolded.)

C. Accordion

(NOTE: The hose will stand severe bending without collapsing. It reduces transfer of vibrations from engine to radiator.)

IX. Pressure cap operation at various temperatures (Transparency 6)

A. Cooling system at normal temperature--The pressure cap fits over the radiator filler tube and seals tightly around the edges to prevent evaporation or surge loss

B. Cooling system very hot with built-up excess pressure--Blow-off valve has calibrated spring which opens to release excess pressure in the cooling system

C. Cooling system during cooling-off period--Vacuum valve opens to allow air to enter the cooling system to prevent collapse of the radiator and hoses

X. Variable-speed fan drive operation (Transparency 7)

A. When engine temperatures are high, the fan speed is increased to aid cooling

B. When engine temperatures are low, the fan speed is decreased to conserve engine power

XI. Reasons for using permanent antifreeze solution

A. Prevents coolant from freezing

B. Has a higher boiling point than water

C. Reduces the corrosive action of water

XII. Operation of the coolant recovery system (Transparency 8)

(NOTE: The radiator should be completely filled with coolant. The coolant reserve tank should be approximately one-third full.)

A. As the cooling system heats up and expands, the excess coolant is forced through the pressure valve in the radiator cap through the radiator overflow tube into the coolant reserve tank

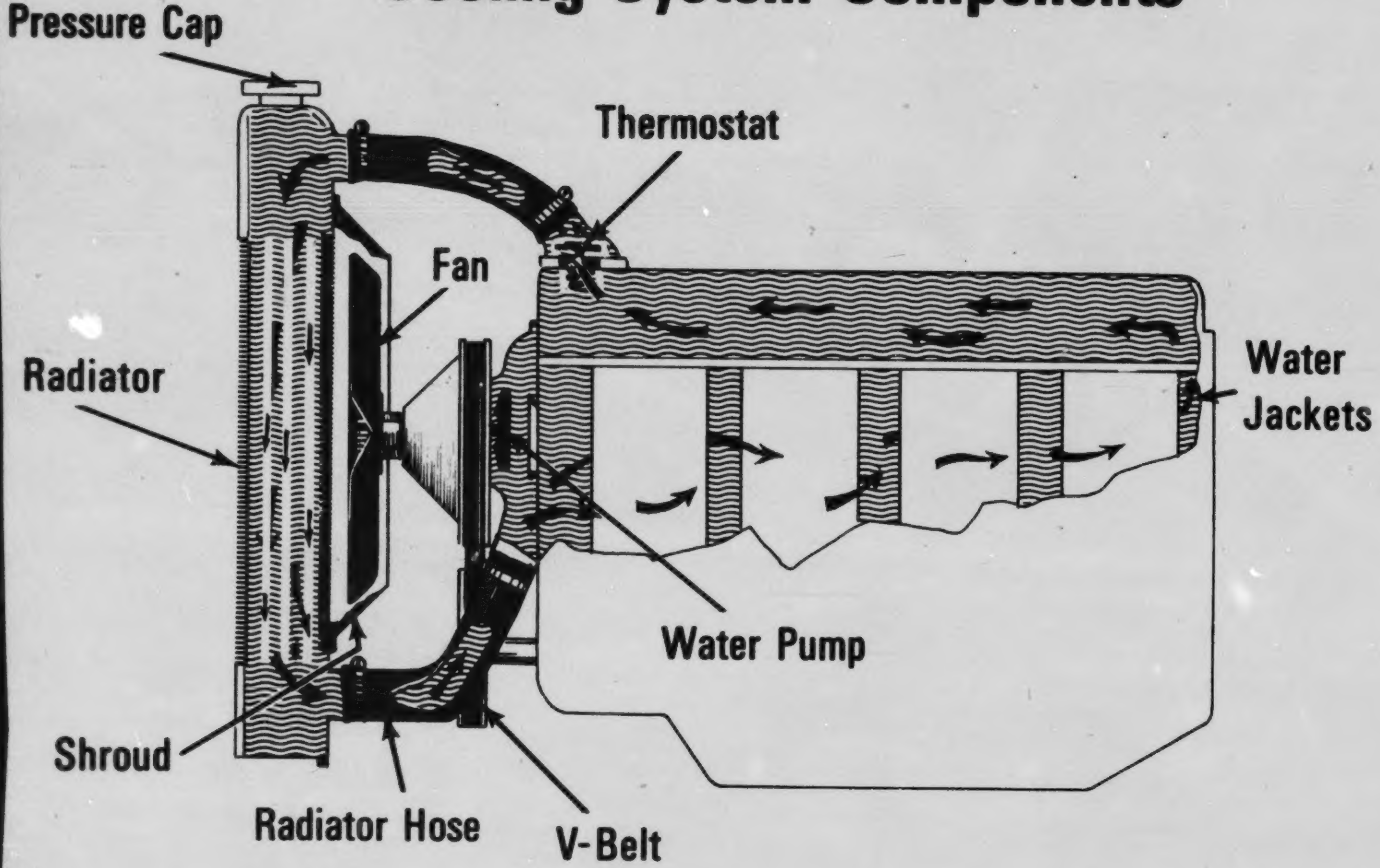
(NOTE: Pressure caps on the coolant recovery systems have an additional seal at the top of the radiator filler neck and therefore will not interchange with standard pressure caps.)

INFORMATION SHEET

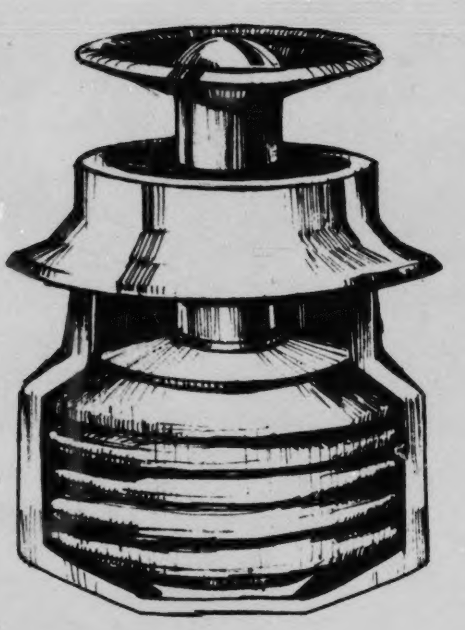
B. As the engine cools, the necessary amount of coolant is pulled back into the radiator through the vent valve in the radiator cap, thus keeping the radiator full at all times

(CAUTION: Do not remove the cap from the radiator when the cooling system is hot. This will prevent scalding or injury.)

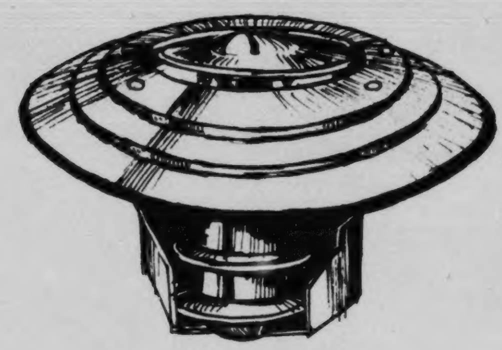
Cooling System Components


Pressure Cap
Thermostat
Fan
Radiator
Water Jackets
Water Pump
Shroud
Radiator Hose
V-Belt

Types of Thermostats

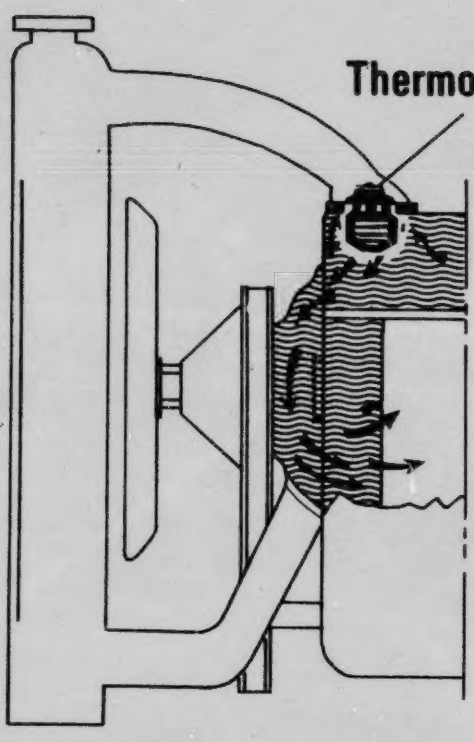


Bellows

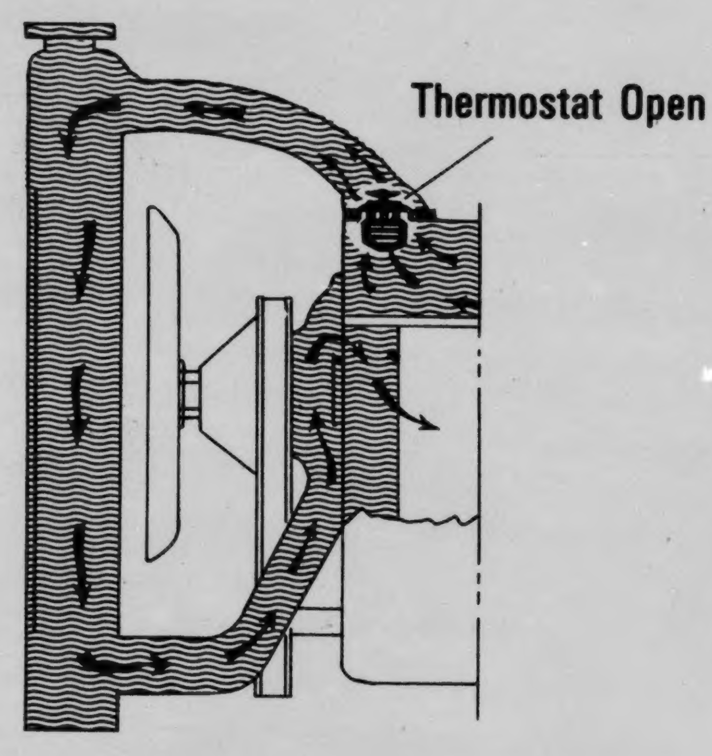


Pellet

Thermostat Operation


Thermostat Closed

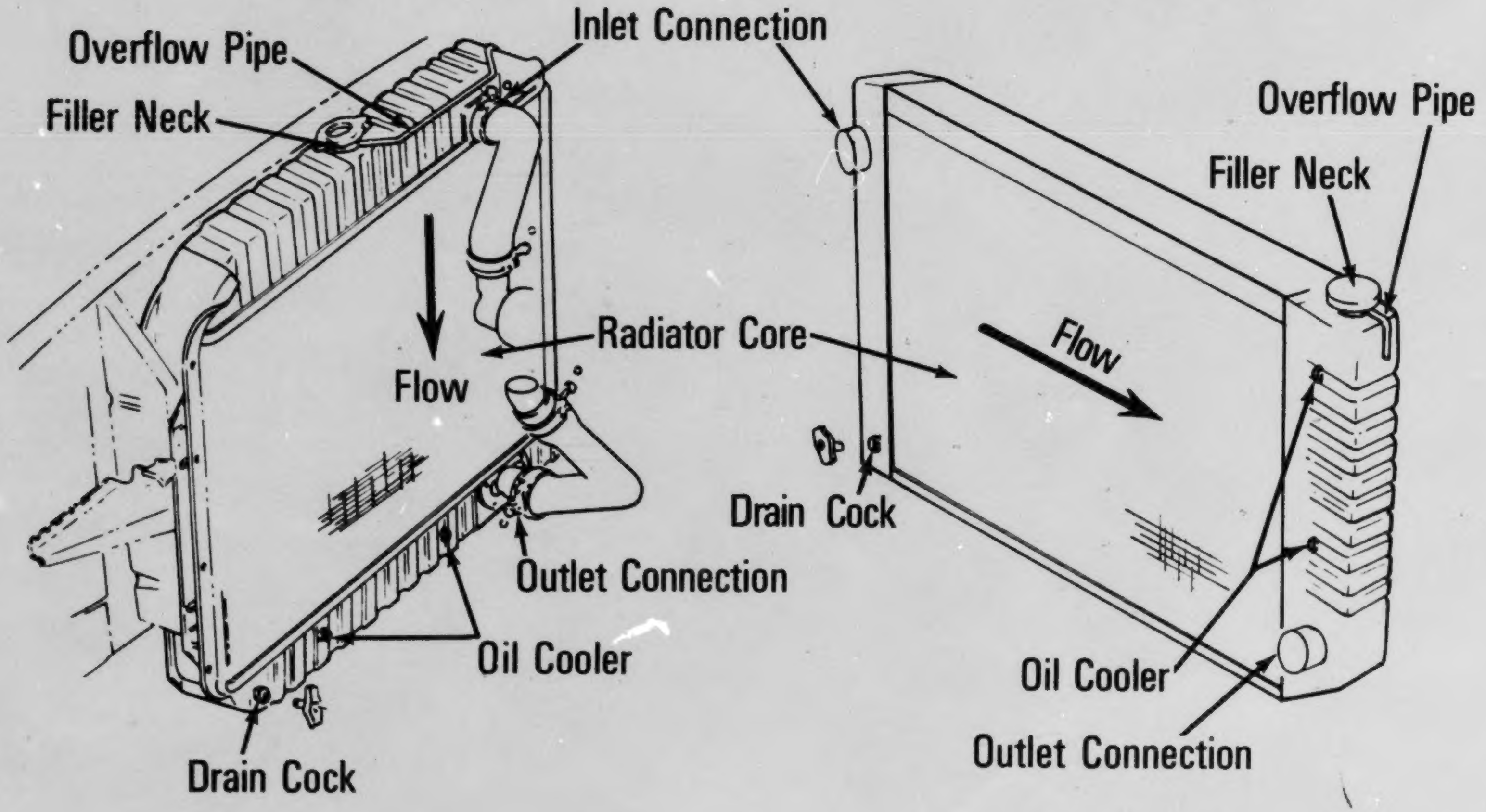
Engine Cold


Thermostat Open

Engine at Operating Temperature

AMT-85-C

Downflow and Crossflow Radiators

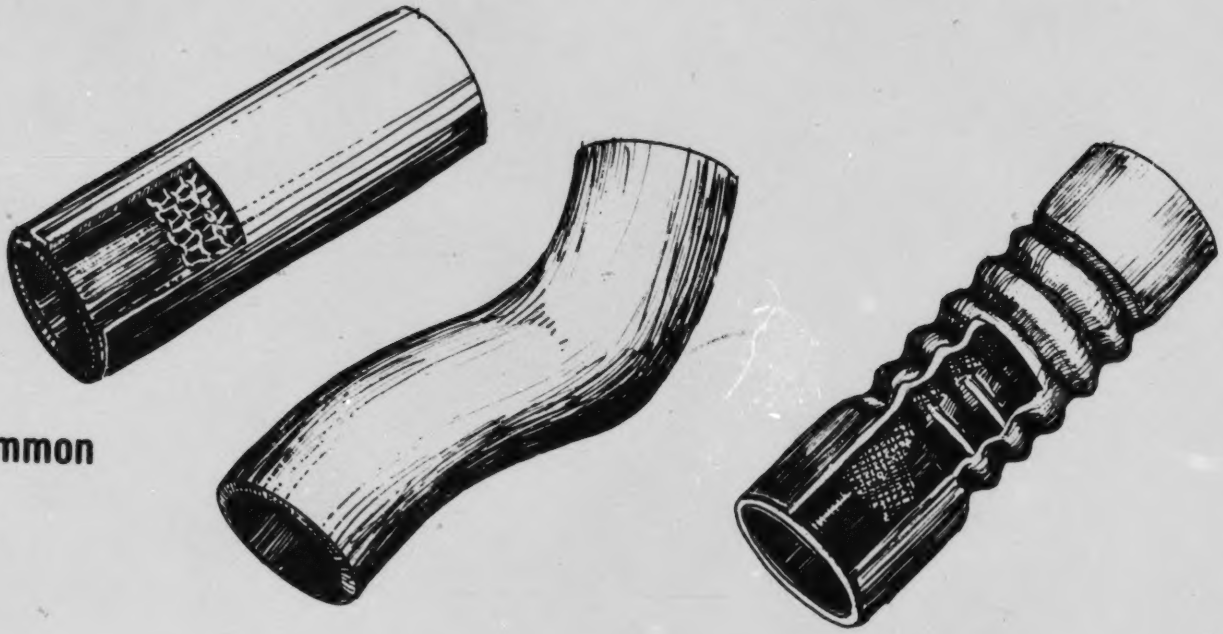


Downflow

Crossflow

Overflow Pipe
Filler Neck
Inlet Connection
Flow
Radiator Core
Outlet Connection
Oil Cooler
Drain Cock
Drain Cock
Overflow Pipe
Filler Neck
Flow
Oil Cooler
Outlet Connection

Types of Radiator Hoses



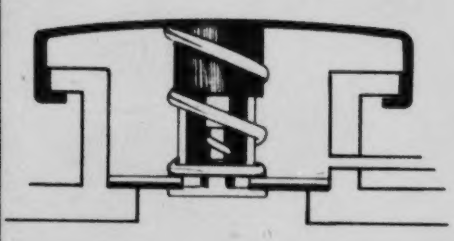
Common

Molded or Shaped

Accordion

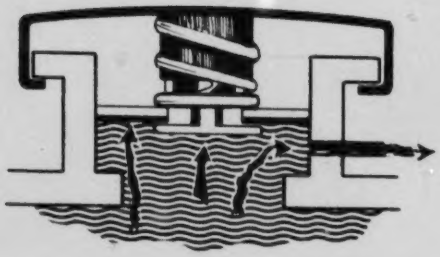
Pressure Cap Operation

Normal Operation



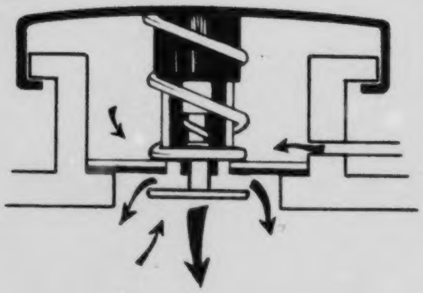
Valves Closed

Excessive Pressure



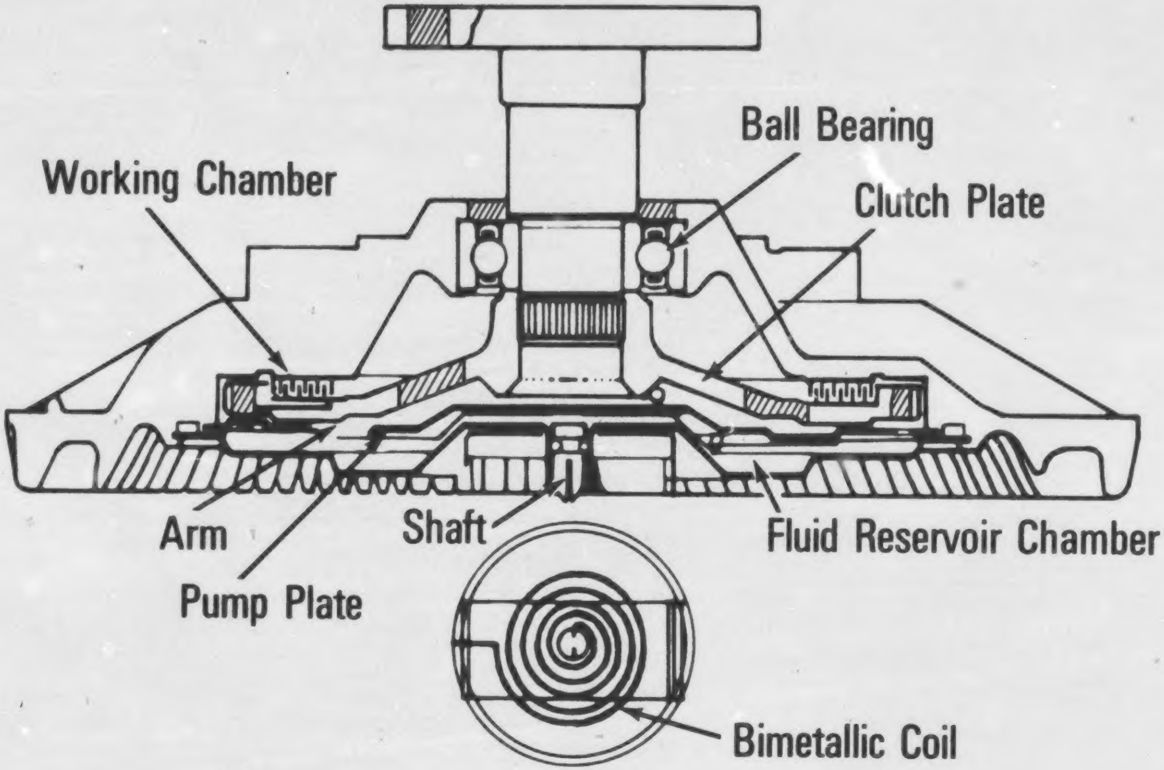
Pressure Valve Open

Cooling-Off Period

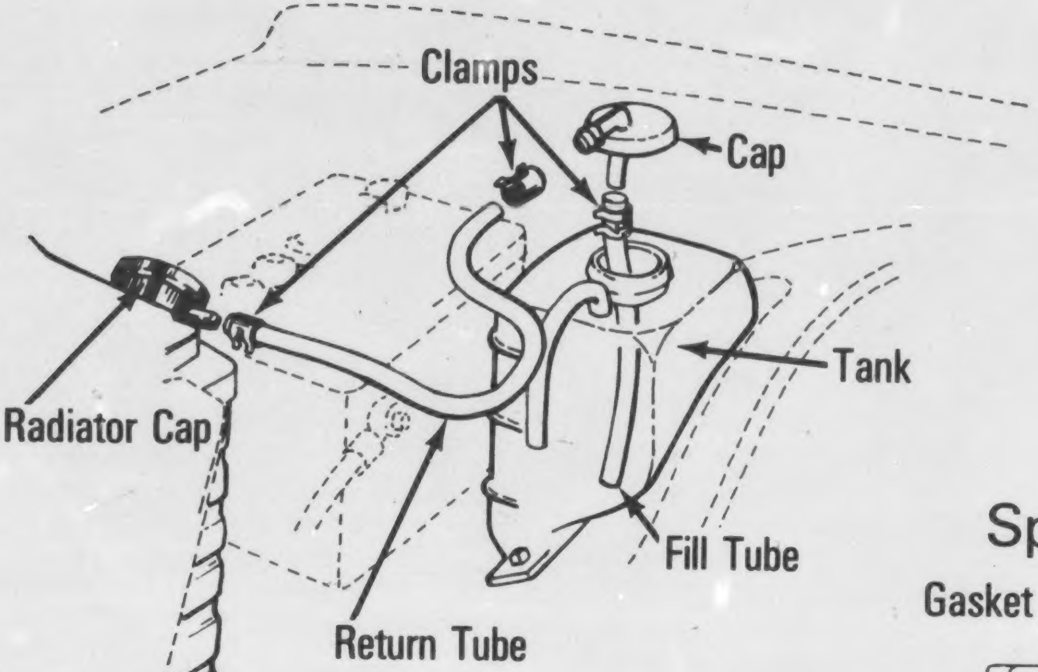


Vacuum Valve Open

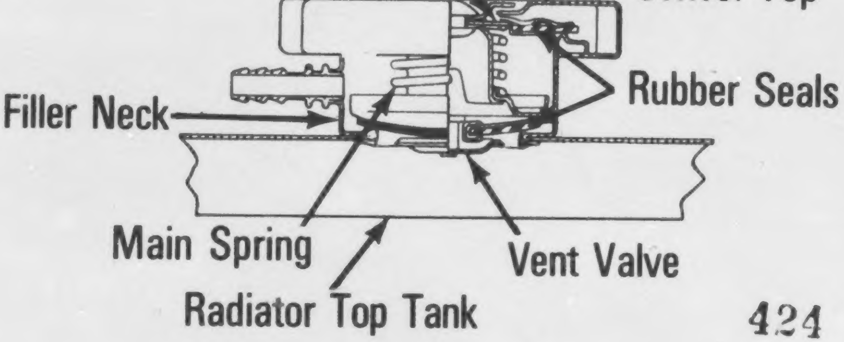
Variable-Speed Fan Drive


Ball Bearing
Working Chamber
Clutch Plate
Arm
Shaft
Fluid Reservoir Chamber
Pump Plate
Bimetallic Coil

Coolant Recovery System


Clamps
Cap
Tank
Radiator Cap
Fill Tube
Return Tube

Special Pressure Cap


Gasket Retainer
Stainless Steel Swivel Top
Rubber Seals
Filler Neck
Main Spring
Vent Valve
Radiator Top Tank

COOLING SYSTEM
UNIT II

JOB SHEET #1--REMOVE, CHECK, AND REPLACE A THERMOSTAT

I. Tools and equipment

  A. Drain pan

  B. Hose clamp pliers

  C. Screwdriver

  D. Sockets, 1/2" - 5/8" (12 mm - 15 mm), 3/8" drive

  E. Ratchet, 3/8" drive

  F. Extension, 6" (150 mm) long, 3/8" drive

  G. Combination end wrenches, 1/2" - 5/8" (12 mm - 15 mm)

  H. Container of water

  I. High temperature thermometer

  J. Gasket scraper

  K. Gasket sealer

  L. Torque wrench

  M. Radiator fill can

II. Procedure

  A. Drain coolant to a level below thermostat

  B. Remove radiator hose connected to thermostat outlet if required

  C. Remove the thermostat housing retaining bolts

  D. Remove the thermostat housing

  E. Remove thermostat

  F. Determine condition of thermostat

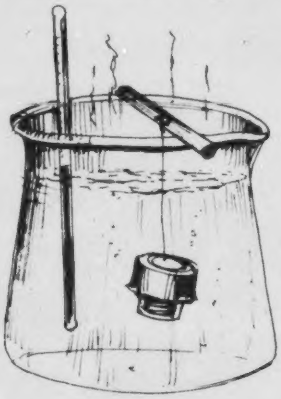
  (NOTE: Discard thermostat if it is excessively rusted, bent, or stuck in an open position.)

JOB SHEET #1

G. Check thermostat opening

1. Suspend thermostat in a container of water with a high temperature thermometer (Figure 1)

FIGURE 1



2. Heat the container; observe the temperature at which the thermostat begins to open and the temperature at full open position

   a. Discard thermostat if it fails to respond at specified temperatures

      (NOTE: The thermostat should start to open at 180° - 185°F [82° - 85°C] and should be fully open at 200° - 202°F [93° - 95°C].)

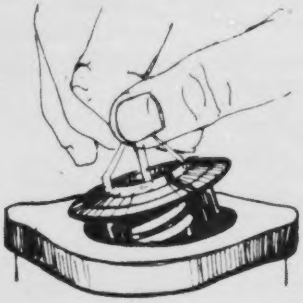
   b. Reinstall thermostat if it checks okay

H. Clean thermostat seat and thermostat housing

(NOTE: Remove all traces of gasket and rust.)

I. Place thermostat into thermostat opening (Figure 2)

FIGURE 2



(NOTE: Make sure bellows or spring on thermostat is placed toward the cylinder block.)

JOB SHEET #1

J. Install new gasket with gasket sealer as required

K. Install thermostat housing; start retaining bolts

L. Tighten bolts uniformly and to specified torque

M. Install hose and tighten clamps securely

N. Fill cooling system

O. Start engine

P. Check for leaks

Q. Recheck the coolant level after the engine is warm

COOLING SYSTEM
UNIT II

JOB SHEET #2--REMOVE AND REPLACE A WATER PUMP

I. Tools and equipment

- A. Drain pan
- B. Combination end wrenches, 1/2" - 3/4" (12 mm - 19 mm)
- C. Sockets, 3/8" - 3/4" (8 mm - 19 mm), 3/8" drive
- D. Ratchet, 3/8" drive
- E. Extension, 6" (150 mm) long, 3/8" drive
- F. Hose clamp pliers
- G. Gasket scraper
- H. Gasket sealer
- I. Torque wrench
- J. Screwdriver
- K. Radiator fill can

II. Procedure

- A. Drain cooling system
- B. Remove drive belts
- C. Remove fan

  (NOTE: Usually the fan must be removed before the fan shroud.)
- D. Remove fan shroud
- E. Determine type of water pump

  (NOTE: Some water pumps are small and are attached to the front engine housing. Other pumps are attached to the block and require lower hose removal.)
- F. Remove lower hose if required
- G. Remove water pump retainer bolts

JOB SHEET #2

H. Remove water pump

I. Clean gasket material and rust from pump and housing gasket surfaces

J. Apply gasket sealer to gasket surfaces

K. Place gasket on water pump

(NOTE: Sometimes it will be necessary to place the gasket on the block for convenience of installation.)

L. Replace water pump; start retainer bolts

M. Tighten water pump retainer bolts uniformly; torque to specifications

N. Replace lower hose

O. Replace fan shroud if used

P. Replace fan assembly

(NOTE: Make sure fan is placed correctly to draw air through the radiator.)

Q. Replace drive belts

R. Adjust belts to manufacturer's specifications

S. Follow manufacturer's recommended procedure for water pump break-in

T. Close radiator drain

U. Fill radiator with coolant

V. Start engine and allow warm-up time

W. Check for leaks

COOLING SYSTEM
UNIT II

JOB SHEET #3--REMOVE AND REPLACE A RADIATOR

I. Tools and equipment

A. Hose clamp pliers

B. Screwdriver

C. End wrenches, 3/8" - 3/4" (8 mm - 19 mm)

D. Ratchet, 3/8" drive

E. Extension, 4" (100 mm) long, 3/8" drive

F. Sockets, 3/8" - 3/4" (8 mm - 19 mm), 3/8" drive

II. Procedure

A. Drain radiator

B. Disconnect upper radiator hose from radiator

C. Disconnect lower radiator hose from radiator

D. Remove fan shroud attaching screws

E. Move fan shroud toward the engine back over the fan assembly

F. Disconnect automatic transmission cooler lines if used

(NOTE: It will be necesary to use a back-up wrench when removing lines to avoid damage to the fittings and radiator.)

G. Remove radiator attaching bolts

H. Remove radiator

I. Clean air passages using compressed air

J. Check the radiator mounting shell for breaks or cracks

K. Replace the radiator

(NOTE: Make sure fan shroud is in place before radiator is replaced.)

L. Position radiator; start attaching bolts

JOB SHEET #3

M. Tighten radiator attaching bolts

N. Replace transmission cooler lines and tighten securely

(NOTE: It will be necessary to use a back-up wrench when tightening lines to prevent damage to fittings and radiator.)

O. Move fan shroud into place, install attaching screws, and tighten securely

P. Inspect hoses to determine if replacement is necessary

Q. Replace lower hose and tighten clamps securely

R. Replace upper hose and tighten clamps securely

S. Close radiator drain cock

T. Refill radiator with recommended coolant

U. Start engine and allow to warm-up

V. Check for coolant leaks

W. Check coolant level

COOLING SYSTEM
UNIT II

JOB SHEET #4--PRESSURE TEST THE COOLING SYSTEM

I. Tools and equipment--Radiator pressure tester

II. Procedure

A. Remove radiator cap

(CAUTION: Never remove the radiator cap quickly when the engine is hot. If cap must be removed when hot, loosen cap to first stop and leave in this position until all pressure is released. Cap can then be removed safely.)

B. Wipe the radiator filler cap seat clean

C. Attach the radiator pressure tester

D. Apply pressure (Figure 1)

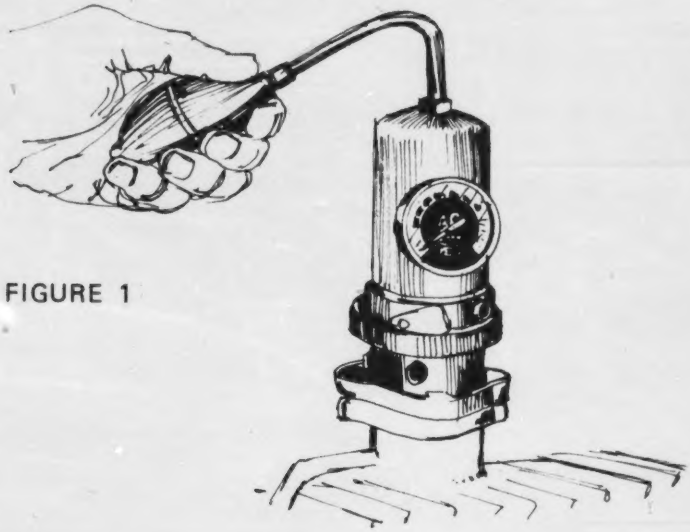


FIGURE 1

(NOTE: Pressure applied should not exceed recommended cooling system pressure by more than 1 psi.)

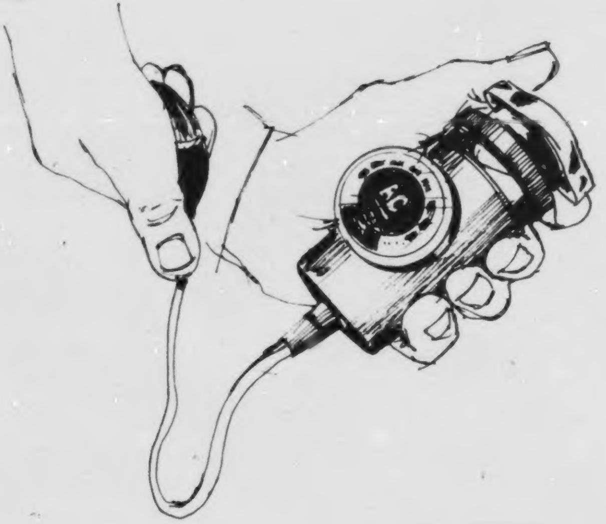
1. If pressure holds steady

(NOTE: The cooling system is not leaking if pressure remains steady.)

JOB SHEET #4

a. Test the pressure cap (Figure 2)

FIGURE 2



(NOTE: Use the radiator pressure tester with adapter. If the cap does not hold the rated pressure, it should be replaced.)

b. Check coolant level

c. Reinstall cap

2. If pressure drops

   a. Check for external leaks in hose connections, expansion plugs, water pump, and radiator

   b. Check for internal leaks

      1) Remove tester

      2) Start and run engine until operating temperature is reached

      3) Reattach pressure tester

      4) Apply cooling system pressure

JOB SHEET #4

5) Increase engine speed to half-throttle

   a) If pressure gauge needle fluctuates, this indicates a combustion leak

      (NOTE: If combustion leaks are evident, the engine will have to be disassembled for repairs.)

   b) If pressure gauge needle does not fluctuate, sharply accelerate engine several times and check for a discharge of water from the tail pipe

      (NOTE: If an abnormal amount of water is discharged at the tail pipe, this could indicate a cracked block or head or a defective head gasket.)

6) Test the pressure cap

   (NOTE: Refer to Figure 2. Use radiator pressure tester with adapter. If the cap does not hold the rated pressure, it should be replaced.)

7) Check coolant level

8) Reinstall cap

COOLING SYSTEM
UNIT II

JOB SHEET #5--REMOVE, INSPECT, AND REPLACE V-BELTS

I. Tools and equipment

   A. Combination end wrenches, 1/2" - 5/8" (12 mm - 15 mm)

   B. Pry bar

   C. V-belt tension gauge

II. Procedure

   A. Locate slotted adjustment holes on brace or component to be adjusted

   B. Loosen necessary bolts to allow component movement

   C. Move component toward block to allow V-belt removal

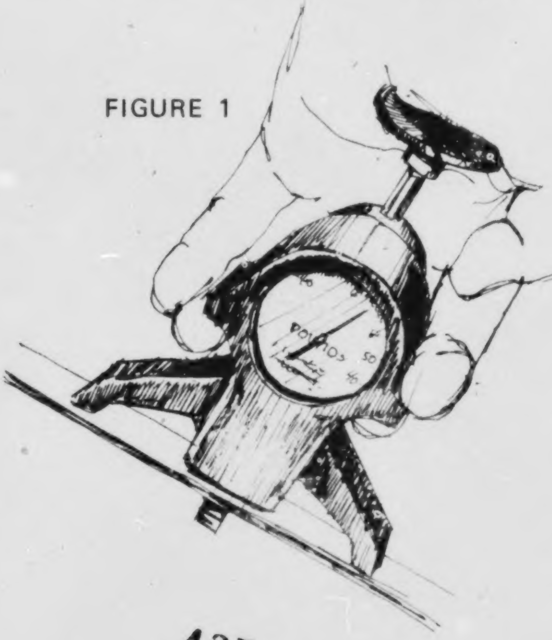
   D. Inspect V-belt

   (NOTE: Inspect for cracks, glazing, fraying, or any condition that will make the belt unreliable or inefficient to use.)

   E. Replace V-belt

   F. Adjust belt tension to manufacturer's specifications (Figure 1)

FIGURE 1



JOB SHEET #5

(NOTE: Tension can also be checked by measuring the amount of belt defection; check manufacturer's specifications for proper defection.)

G. Hold tension on belt and tighten all brackets and braces securely

H. Recheck tension

(NOTE: It will be necessary to readjust new belts after a few hours of operation due to stretching.)

COOLING SYSTEM
UNIT II

JOB SHEET #6--TEST ANTIFREEZE SOLUTION

I. Equipment--Antifreeze hydrometer tester

II. Procedure

A. Start engine and allow time for coolant to warm up to operating temperature

B. Remove radiator cap

(NOTE: Never remove the radiator cap quickly when the engine is hot. Loosen cap slowly to first stop and leave in this position until all pressure is released. Cap can then be removed safely.)

C. Draw coolant into tester and empty several times to equalize the temperature of all parts

D. Draw coolant into tester

E. Read the first number or letter on the float above the liquid surface

F. Note temperature of coolant

G. Measure antifreeze content of the water by comparing the readings with the chart on the tester

(NOTE: The antifreeze content should be such that the cooling system would be protected to 10°F [5°C] lower than the coldest temperature expected.)

H. Add antifreeze if necessary

(NOTE: Allow room for expansion.)

COOLING SYSTEM
UNIT II

TEST

1. Write the purpose of the cooling system.

2. Match the terms on the right to the correct definitions.

_____a. Device generally mounted on the water pump hub assembly used to pull a large volume of air through the openings in the radiator core

_____b. Heat-controlled valve in the cooling system used to regulate the flow of coolant between the cylinder block and radiator

_____c. Belt turned by a pulley on the front of the crankshaft used to drive the water pump, fan, and other engine accessories

_____d. Centrifugal pump mounted at the front of the cylinder block to circulate the coolant throughout the cooling system

_____e. Passage through the block and cylinder head that allows the coolant to circulate around the cylinders, valves, and combustion chambers

_____f. Cap which increases the pressure within the cooling system several pounds per square inch, allowing the coolant to circulate at higher temperatures without evaporation or surge loss

_____g. Device for holding a considerable volume of coolant in close contact with a large amount of air so that heat may be transferred from the coolant to the air

_____h. Funnel-like structure attached to the radiator and extending around and behind the fan; used to make the fan more effective in pulling air through the radiator

_____i. Hose used to connect the radiator to the engine

1. Water pump
2. Water jacket
3. Radiator
4. Fan
5. Shroud
6. Thermostat
7. Pressure cap
8. Radiator hose
9. V-belt

3. Distinguish between the two types of thermostats by placing a "B" in front of the statement describing a bellows type and a "P" in front of the pellet type.

______a. Contains a special liquid which heat causes to expand and open the thermostat valve

______b. Contains copper-impregnated wax which heat causes to expand and open the thermostat valve

4. Describe the operation of the thermostat during the following conditions.

a. Engine is cold

b. Engine is at operating temperature

5. List three jobs that the cooling system must perform.

a.

b.

c.

6. Distinguish between types of radiators by placing a "D" in front of the statements describing a downflow radiator and a "C" in front of those describing a crossflow radiator.

______a. Flow of coolant from top to bottom

______b. Tanks on right and left sides

______c. Tanks on top and bottom

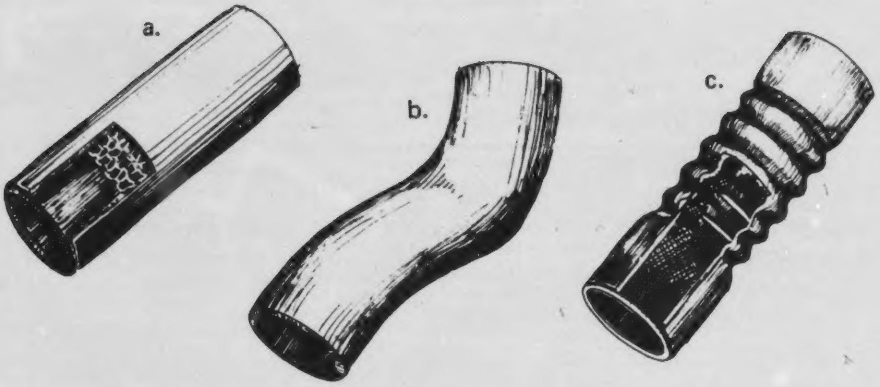
______d. Flow of coolant from side to side across radiator

7. Describe the following methods of cooling the internal combustion engine.

a. Liquid

b. Air

8. Identify the following types of radiator hoses.



a.____________________

b.____________________

c.____________________

9. Describe the pressure cap operation during each of the following temperatures.

a. Cooling system at normal temperature

b. Cooling system very hot with built-up excess pressure

c. Cooling system during cooling-off period

10. Describe the operation of the variable-speed fan drive.

11. List three reasons for using a permanent antifreeze solution in the cooling system at all times.

a.

b.

c.

12. Describe the operation of a coolant recovery system.

13. Demonstrate the ability to:
    - a. Remove, check, and replace a thermostat.
    - b. Remove and replace a water pump.
    - c. Remove and replace a radiator.
    - d. Pressure test the cooling system.
    - e. Remove, inspect, and replace V-belts.
    - f. Test antifreeze solution.

    (NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

COOLING SYSTEM
UNIT II

ANSWERS TO TEST

1. To keep the engine at its most efficient operating temperature during all engine speeds and driving conditions

2. a. 4
   b. 6
   c. 9
   d. 1
   e. 2
   f. 7
   g. 3
   h. 5
   i. 8

3. a. B
   b. P

4. Description should include:
   a. Engine is cold--Thermostat shuts off flow of coolant from the engine to the radiator to allow quicker engine warm-up
   b. Engine is at operating temperature--Thermostat is open and allows coolant to circulate through the system

5. a. Remove surplus or unwanted heat
   b. Maintain an efficient temperature under all operating conditions
   c. Bring an engine up to operating temperature as soon after starting as possible

6. a. D
   b. C
   c. D
   d. C

7. Description should include:
   a. Liquid--Uses circulating coolant for engine heat removal
   b. Air--Uses a fan, cooling fins, and engine shrouding for heat removal

8. a. Common

   b. Molded or shaped

   c. Accordion

9. Description should include:

   a. The pressure cap fits over the radiator filler tube and seals tightly around the edges to prevent evaporation or surge loss

   b. Blow-off valve has calibrated spring which opens to release excess pressure in the cooling system

   c. Vacuum valve opens to allow air to enter the cooling system to prevent collapse of the radiator and hoses

10. Description should include:

    a. When engine temperatures are high, the fan speed is increased to aid cooling

    b. When engine temperatures are low, the fan speed is decreased to conserve engine power

11. a. Prevents coolant from freezing

    b. Has a higher boiling point than water

    c. Reduces the corrosive action of water

12. Description should include:

    a. As the cooling system heats up and expands, the excess coolant is forced through the pressure valve in the radiator cap through the radiator overflow tube into the coolant reserve tank

    b. As the engine cools, the necessary amount of coolant is pulled back into the radiator through the vent valve in the radiator cap, thus keeping the radiator full at all times

13. Performance skills evaluated to the satisfaction of the instructor

ENGINE LUBRICATION SYSTEM
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify components of the engine lubrication system and match the components to the correct purposes. The student should be able to identify types of oil filters and list additives most commonly used in engine oil. The student should be able to discuss oil classifications and demonstrate the ability to change the oil and filter of an engine. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the engine lubrication system to the correct definitions.
2. List the purposes of the engine lubrication system.
3. Identify the components of the engine lubrication system.
4. Match the components of the engine lubrication system to the correct purposes.
5. Identify the types of oil filters.
6. Name the methods of classifying engine oil.
7. Discuss oil viscosity classifications.
8. Match oil service designation letters to the correct descriptions.
9. List points to consider when selecting engine oil.
10. List additives found in engine oil.
11. Demonstrate the ability to:
    a. Change oil in an engine.
    b. Change an oil filter.

ENGINE LUBRICATION SYSTEM
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information sheet.
- F. Demonstrate and discuss procedures outlined in the job sheets.
- G. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Demonstrate the ability to accomplish the procedures outlined in the job sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
    1. TM 1--Components of the Engine Lubrication System
    2. TM 2--Types of Oil Filters
    3. TM 3--SAE Viscosity Classifications

D. Job sheets

   1. Job Sheet #1--Change Oil in an Engine

   2. Job Sheet #2--Change an Oil Filter

E. Test

F. Answers to test

II. References:

A. Toboldt, William K., and Purvis, Jud. *Motor Services Automotive Encyclopedia.* Homewood, Illinois: Goodheart-Willcox Co., 1965.

B. Stockel, Martin W. *Auto Service and Repair.* Homewood, Illinois: Goodheart-Willcox Co., 1969.

C. *Fuel, Lubricants and Coolants.* Fundamentals of Service series. Moline, Illinois: Deere and Co., 1970.

ENGINE LUBRICATION SYSTEM
UNIT III

INFORMATION SHEET

I. Terms and definitions

   A. Friction--Resistance to movement between any two objects placed in contact with each other

   B. Viscosity--Measure of the ability of an oil to resist flowing

   C. Viscosity index (VI)--Measure of the ability of an oil to resist changes in viscosity when heated

   D. Multi-viscosity--Oil that meets the low temperature requirements of a light oil and the high temperature requirements of a heavy oil

   E. API--Service classifications established by the American Petroleum Institute

   F. SAE--Viscosity ratings established by the Society of Automotive Engineers

   G. MIL--Specifications prepared by the Ordnance Department of the U.S. Army, Navy, and Air Force

   H. ASTM--Engine sequence tests adopted by the American Society for Testing Materials

II. Purposes of the engine lubrication system

   A. Lubricates moving parts to minimize friction

   B. Acts as a cooling agent to remove heat from engine parts

   C. Forms a seal between piston rings and cylinder walls

   D. Keeps parts clean

   E. Absorbs shock between bearings and other parts

III. Components of the engine lubrication system (Transparency 1)

   A. Oil galleries

   B. Oil filter

   C. Oil pressure relief valve

INFORMATION SHEET

D. Oil pump

E. Oil pickup

F. Oil pan

IV. Purposes of the components of the lubrication system (Transparency 1)

A. Oil gallery--Pipe or passageway in the engine used to carry engine oil from one area to another

B. Oil filter--Device used to strain the engine oil thus removing abrasive particles

C. Oil pressure relief valve--Valve in the lubrication system designed to limit maximum oil pressure

D. Oil pump--Device used to force oil under pressure to various parts of the engine for lubrication

E. Oil pickup--Device which allows the pump to pick up oil from the oil pan

F. Oil pan--Cover on the bottom of the engine which provides a reservoir for the engine oil

V. Types of oil filters (Transparency 2)

A. Sealed cartridge

B. Replaceable element

VI. Engine oil classifications (Transparency 3)

A. Viscosity rating

B. Service or performance rating

VII. Oil viscosity classifications (Transparency 3)

A. Single grade

1. Each grade is compounded for a specific temperature range

(NOTE: Engine oil grades range from 5W to 40W.)

2. The larger the number the heavier the oil

B. Multi-grade--Designed for use over a broader temperature range

INFORMATION SHEET

VIII. Oil service designation letters and their descriptions

A. SA--Oil without additive except that it may contain pour and/or foam depressants; utility engine service

B. SB--Oil which provides some anti-oxidant and anti-scuff capabilities; minimum duty gasoline engine service

C. SC--Oil which meets the 1964-1967 requirements of the automobile manufacturers and provides low temperature anti-sludge and anti-rust performance; intended primarily for use in passenger cars

D. SD--Oil which meets the 1968-1971 requirements of the automobile manufacturers and provides low temperature anti-sludge and anti-rust performance; intended primarily for use in passenger cars

E. SE--Oil which meets the 1972 requirements of the automobile manufacturers and provides high temperature anti-oxidation, low temperature anti-sludge and anti-rust performance; intended primarily for use in passenger cars

IX. Points to consider when selecting engine oil

A. Use oil of the proper viscosity for the average temperature in which the vehicle will operate

B. Use oil of the proper service rating as recommended by the manufacturer

(NOTE: The service rating should be equal to or better than that recommended by the engine manufacturer.)

C. Select oils which have been performance tested

D. Do not mix oils of various service or viscosity ratings

X. Additives found in engine oil

A. Anti-corrosion

(NOTE: Anti-corrosion additives protect bearings and other metal surfaces from corrosion attack by acids created by combustion gases in the crankcase.)

B. Oxidation inhibitor

(NOTE: Oxidation inhibitors protect oil molecules from combining with oxygen to stop formation of acid, varnish, and sludge.)

INFORMATION SHEET

C. Anti-rust

(NOTE: Anti-rust additives cling to metal surfaces and repel water droplets to prevent rusting while the engine is not in operation.)

D. Viscosity index improver

(NOTE: The viscosity index improver helps an oil give top lubricating protection at both high and low temperatures by giving the oil the beneficial properties of both light and heavy oils.)

E. Pour point depressant

(NOTE: Pour point depressants prevent wax crystals in oil from getting too thick in cold temperatures or too thin in hot temperatures.)

F. Extreme pressure

(NOTE: Extreme pressure additives assure lubrication where extreme pressures are encountered.)

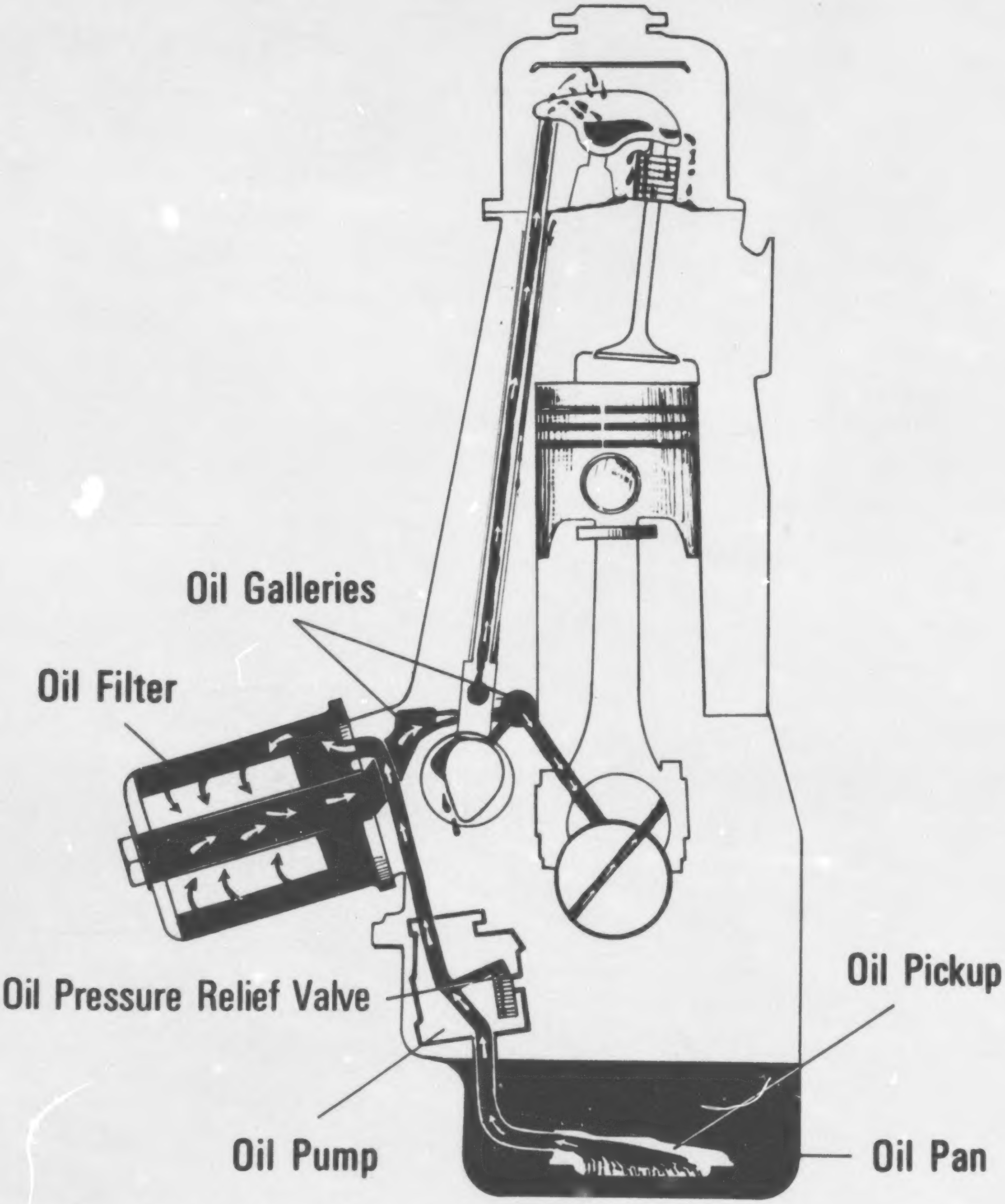
G. Detergent dispersant

(NOTE: A detergent dispersant suspends particles of contaminations in oil to keep metal surfaces clean and to prevent deposit formation.)

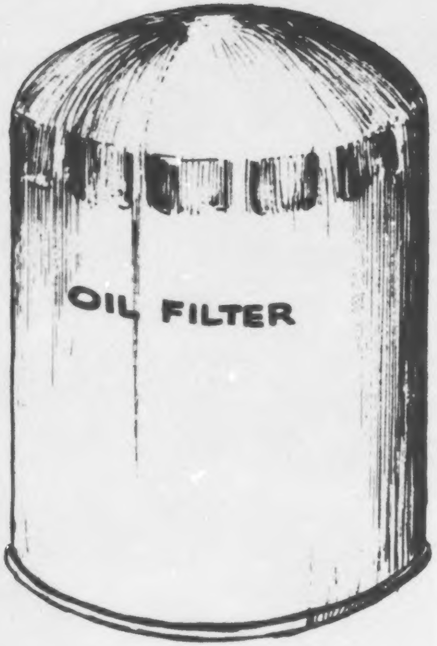
H. Foam inhibitor

(NOTE: Foam inhibitors prevent the formation of air bubbles in the oil which would restrict lubrication.)

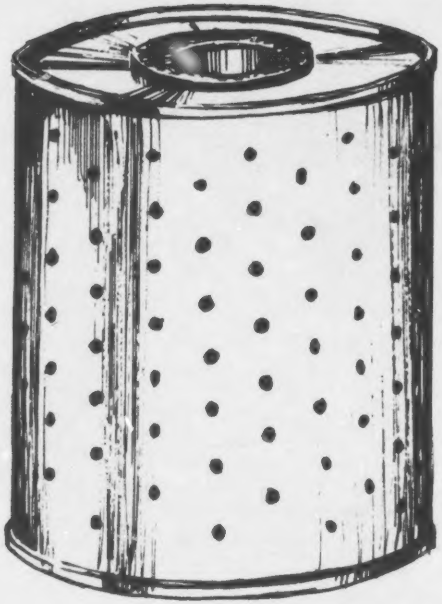
Components of the Engine Lubrication System


Oil Galleries
Oil Filter
Oil Pressure Relief Valve
Oil Pickup
Oil Pump
Oil Pan

Types of Oil Filters



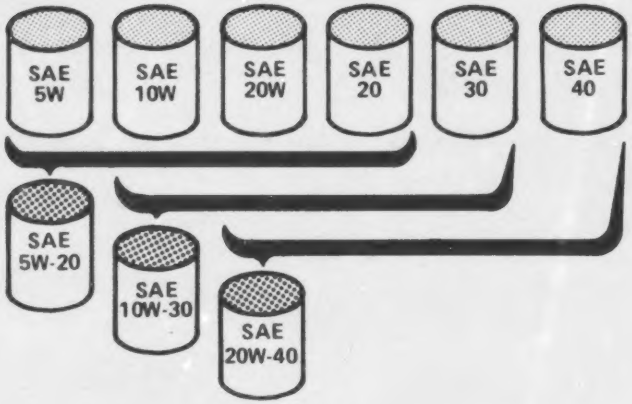
Sealed Cartridge



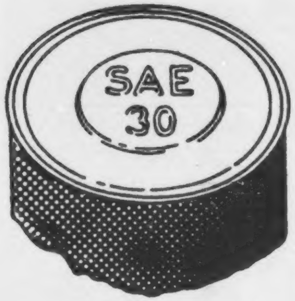
Replaceable Element

AM I - 129-C

SAE
Viscosity Classifications


SAE 5W
SAE 10W
SAE 20W
SAE 20
SAE 30
SAE 40
SAE 5W-20
SAE 10W-30
SAE 20W-40

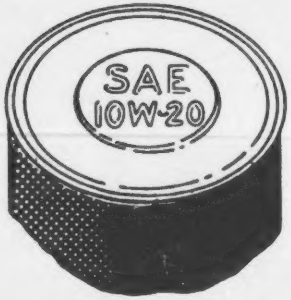
A Multi-Viscosity Oil Can Replace
Several Single-Viscosity Oils (When Recommended)



Single-Viscosity Oil

Oil Viscosity is
Marked On Oil Containers

Multi-Viscosity Oil



ENGINE LUBRICATION SYSTEM
UNIT III

JOB SHEET #1--CHANGE OIL IN AN ENGINE

I. Tools and equipment

   A. Drain pan

   B. Wrench suitable for drain plug removal

   C. Jack

   D. Jack stands

   E. Oil spout

   F. Service sticker

   G. Shop towels

II. Procedure

   A. Support vehicle on jack stands

   B. Position drain pan under engine drain plug

   C. Remove drain plug

   (CAUTION: Use care to avoid being burned by hot oil.)

   D. Allow the oil sufficient time to drain

   (NOTE: Observe oil condition and color that might make further service necessary.)

   E. Replace oil filter as required

   F. Replace drain plug

   (NOTE: Make sure the gasket, if used, is in place and the drain plug is securely tightened.)

   G. Remove jack stands and lower car to floor

   H. Lift hood

   I. Remove oil filler cap

   (NOTE: Dirt and grease should be wiped away from filler cap before removal.)

JOB SHEET #1

J. Refill the crankcase to recommended level with the proper motor oil

(NOTE: Make sure the tops of the oil cans and the filling spout are clean.)

K. Clean and replace oil filler cap

L. Start engine and operate it for a few minutes at low rpm

M. Check for oil leaks

N. Shut off engine

O. Check oil level on dipstick

(NOTE: Add oil as required by manufacturer's specifications. Do not overfill.)

P. Make out service sticker and apply to inner door surface

(NOTE: Make sure date, mileage, and type of oil are included on service sticker.)

ENGINE LUBRICATION SYSTEM
UNIT III

JOB SHEET #2--CHANGE AN OIL FILTER

I. Tools and equipment

   A. Shop towels

   B. Container to catch waste oil

   C. Suitable wrenches to remove filter

   D. Fender covers

   E. Suction gun

   F. Jack

   G. Jack stands

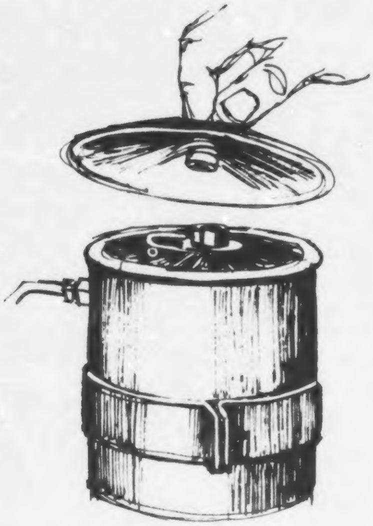
II. Procedure

   A. Replaceable element type oil filter on upper part of engine

      1. Clean dirt from filter cover

      2. Remove oil filter cover (Figure 1)

FIGURE 1



JOB SHEET #2

3. Remove oil filter element

   (NOTE: Use care to avoid spilling oil on vehicle.)

4. Remove remaining oil from filter housing by removing drain plug from housing or use the suction gun to draw out the oil

5. Clean filter cover and housing

6. Remove old filter gasket

7. Install new filter gasket into filter cover

   (NOTE: Install other small rubber gaskets as required.)

8. Install new filter element

9. Install filter cover

   (NOTE: Make sure the gasket is in place.)

10. Tighten filter cover securely

11. Add oil or refill crankcase as required

12. Start engine

13. Check for leaks

14. Shut off engine

15. Check oil level on dipstick

    (NOTE: Add oil as required. Do not overfill.)

16. Make out service sticker indicating date and mileage oil filter was changed

B. Replaceable element type oil filter on lower part of engine

   1. Support front of vehicle on jack stands

   2. Position drain pan under oil filter

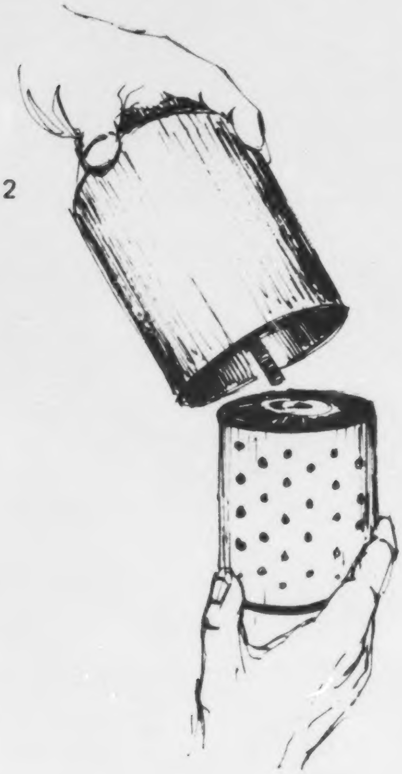
   3. Remove oil filter housing bolt

   4. Remove oil filter housing

JOB SHEET #2

5. Remove oil filter element from filter housing (Figure 2)

FIGURE 2



6. Clean the filter housing
7. Remove old oil filter housing gasket
8. Install new oil filter housing gasket

   (NOTE: Make sure the new gasket is placed correctly.)
9. Install new oil filter element in filter housing
10. Install oil filter housing and tighten bolt securely
11. Remove jack stands and lower car to floor
12. Add oil or refill crankcase as required
13. Start engine
14. Check for leaks

JOB SHEET #2

15. Shut off engine
16. Check oil level on dipstick

    (NOTE: Add oil as required. Do not overfill.)

17. Make out service sticker indicating date and mileage oil filter was changed

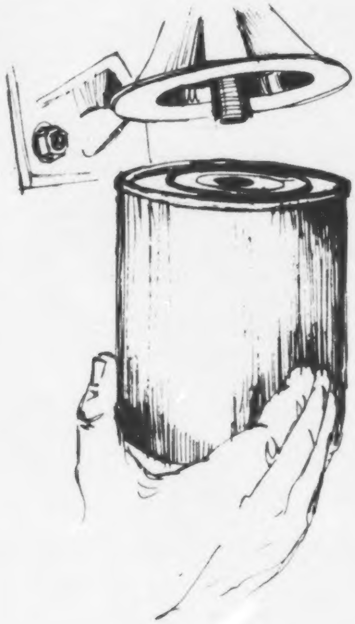
C. Sealed cartridge type oil filter

1. Support front of vehicle on jack stands if required
2. Place drain pan under oil filter
3. Remove oil filter cartridge with suitable tool

   (NOTE: Turn counterclockwise to remove.)

4. Lubricate the sealing gasket on the new oil filter cartridge with clean motor oil if required
5. Replace oil filter cartridge; tighten to manufacturer's recommendation (Figure 3)

FIGURE 3



CHANGING SEALED CARTRIDGE OIL FILTER

(NOTE: Usually hand tightening is sufficient.)

JOB SHEET #2

6. Remove jack stands and lower car to floor
7. Add oil or refill crankcase as required
8. Start engine
9. Check for leaks
10. Shut off engine
11. Check oil level on dipstick

    (NOTE: Add oil as required. Do not overfill.)
12. Make out service sticker indicating date and mileage oil filter was changed

ENGINE LUBRICATION SYSTEM
UNIT III

TEST

1. Match the terms on the right to the correct definitions.

   _____a. Engine sequence tests adopted by the American Society for Testing Materials

   _____b. Oil that meets the low temperature requirements of a light oil and the high temperature requirements of a heavy oil

   _____c. Resistance to movement between any two objects placed in contact with each other

   _____d. Specifications prepared by the Ordnance Department of the U.S. Army, Navy, and Air Force

   _____e. Measure of the ability of an oil to resist changes in viscosity when heated

   _____f. Service classifications established by the American Petroleum Institute

   _____g. Measure of the ability of an oil to resist flowing

   _____h. Viscosity ratings established by the Society of Automotive Engineers

   1. Friction
   2. API
   3. Viscosity index (VI)
   4. SAE
   5. Viscosity
   6. MIL
   7. ASTM
   8. Multi-viscosity

2. List the purposes of the engine lubrication system.

   a.

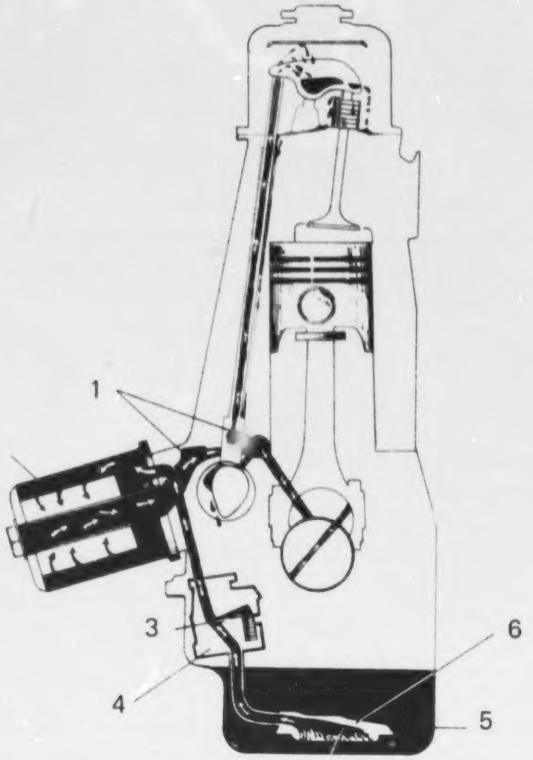
   b.

   c.

   d.

   e.

3. Identify each component of the engine lubrication system shown in the diagram below.



_____a. Oil pressure relief valve

_____b. Oil pickup

_____c. Oil pump

_____d. Oil galleries

_____e. Oil pan

_____f. Oil filter

4. Match the lubrication system components on the right to the correct purposes.

_____a. Device used to force oil under pressure to various parts of the engine for lubrication

_____b. Cover on the bottom of the engine which provides a reservoir for the engine oil

_____c. Device used to strain the engine oil thus removing abrasive particles

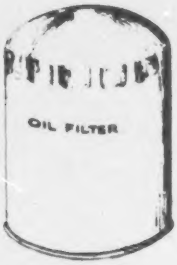
_____d. Pipe or passageway in the engine used to carry engine oil from one area to another

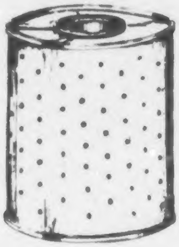
_____e. Device which allows the pump to pick up oil from the oil pan

_____f. Valve in the lubrication system designed to limit maximum oil pressure

1. Oil gallery
2. Oil filter
3. Oil pressure relief valve
4. Oil pump
5. Oil pickup
6. Oil pan

5. Identify the following oil filters.





a. ______________________ b. ______________________

6. Name the two methods of classifying engine oil.

a.

b.

7. Discuss oil viscosity classifications.

   a. Single grade

      1)

      2)

   b. Multi-grade--

8. Match the letter designations on the right to the correct descriptions.

   _____a. Oil which meets the 1972 requirements of the automobile manufacturers and provides high temperature anti-oxidation; low temperature anti-sludge and anti-rust performance; intended primarily for use in passenger cars

   _____b. Oil without additive except that it may contain pour and/or foam depressants; utility engine service

   _____c. Oil which provides some anti-oxidant and anti-scuff capabilities; minimum duty gasoline engine service

   _____d. Oil which meets the 1964-1967 requirements of the automobile manufacturers and provides low temperature anti-sludge and anti-rust performance; intended primarily for use in passenger cars

   _____e. Oil which meets the 1968-1971 requirements of the automobile manufacturers and provides low temperature anti-sludge and anti-rust performance; intended primarily for use in passenger cars

   1. SA
   2. SB
   3. SC
   4. SD
   5. SE

9. List points to consider when selecting engine oil.

   a.

   b.

   c.

   d.

10. List eight additives found in engine oil.

    a.

    b.

    c.

    d.

    e.

    f.

    g.

    h.

11. Demonstrate the ability to:

    a. Change oil in an engine.

    b. Change an oil filter.

    (NOTE: If the above activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

ENGINE LUBRICATION SYSTEM
UNIT III

ANSWERS TO TEST

1.
   - a. 7
   - b. 8
   - c. 1
   - d. 6
   - e. 3
   - f. 2
   - g. 5
   - h. 4
2.
   - a. Lubricates moving parts to minimize friction
   - b. Acts as a cooling agent to remove heat from engine parts
   - c. Forms a seal between piston rings and cylinder walls
   - d. Keeps parts clean
   - e. Absorbs shock between bearings and other parts
3.
   - a. 3
   - b. 6
   - c. 4
   - d. 1
   - e. 5
   - f. 2
4.
   - a. 4
   - b. 6
   - c. 2
   - d. 1
   - e. 5
   - f. 3
5.
   - a. Sealed cartridge
   - b. Replaceable element
6.
   - a. Viscosity rating
   - b. Service or performance rating
7. Discussion should include:
   - a. Single grade
     - 1) Each grade is compounded for a specific temperature range
     - 2) The larger the number the heavier the oil
   - b. Multi-grade--Designed for use over a broader temperature range

8. a. 5

b. 1

c. 2

d. 3

e. 4

9. a. Use oil of the proper viscosity for the average temperature in which the vehicle will operate

b. Use oil of the proper service rating as recommended by the manufacturer

c. Select oils which have been performance tested

d. Do not mix oils of various service or viscosity ratings

10. a. Anti-corrosion

b. Oxidation inhibitor

c. Anti-rust

d. Viscosity index improver

e. Pour point depressant

f. Extreme pressure

g. Detergent dispersant

h. Foam inhibitor

11. Performance skills evaluated to the satisfaction of the instructor

EXHAUST SYSTEM
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to describe the construction and operation of a conventional exhaust system and a system with a catalytic converter. The student should be able to remove and replace the components of the exhaust system. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Write the purposes of the exhaust system.
2. Match terms associated with the exhaust system to the correct definitions.
3. Identify types of mufflers.
4. Describe the operation of the manifold heat control valve.
5. Describe the construction and operation of a catalytic converter.
6. Identify tools used for exhaust system service.
7. Distinguish between single and dual exhaust systems.
8. List safety precautions for preventing carbon monoxide poisoning.
9. Discuss the causes of internal and external corrosion of the exhaust system.
10. Identify the basic components of the exhaust gas recirculating system.
11. Discuss the purpose of the exhaust gas recirculating system.
12. Demonstrate the ability to:
    a. Service a manifold heat control valve.
    b. Remove and replace an exhaust manifold.
    c. Remove and replace an exhaust pipe.
    d. Remove and replace a muffler.
    e. Remove and replace a catalytic converter and its heat shields.
    f. Remove and replace a tail pipe.

EXHAUST SYSTEM
UNIT IV

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined in the job sheets.

   G. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Demonstrate the ability to accomplish the procedures outlined in the job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Exhaust System Components

      2. TM 2--Types of Mufflers

      3. TM 3--Operation of Manifold Heat Control Valve

4. TM 4--Catalytic Converter and Heat Shields
5. TM 5--Tools for Exhaust System Service
6. TM 6--Types of Exhaust Systems
7. TM 7--Exhaust Gas Recirculating System

D. Job sheets

1. Job Sheet #1--Service a Manifold Heat Control Valve
2. Job Sheet #2--Remove and Replace an Exhaust Manifold
3. Job Sheet #3--Remove and Replace an Exhaust Pipe
4. Job Sheet #4--Remove and Replace a Muffler
5. Job Sheet #5--Remove and Replace a Catalytic Converter
6. Job Sheet #6--Remove and Replace a Tail Pipe

E. Test

F. Answers to test

II. References:

A. Toboldt, William K., and Purvis, Jud. *Motor Services Automotive Encyclopedia.* Homewood, Illinois: Goodheart-Willcox Co., 1965.

B. Stockel, Martin W. *Auto Service and Repair.* Homewood, Illinois: Goodheart-Willcox Co., 1969.

C. *Chrysler, Plymouth, Dodge Chassis Service Manual.* Detroit, Michigan: Chrysler Corp., 1976.

D. *Chevrolet Service Manual.* Detroit, Michigan: Chevrolet Motor Div./General Motors Corp., 1974.

EXHAUST SYSTEM
UNIT IV

INFORMATION SHEET

I. Purposes of exhaust system

   A. Conduct the burned gases from the engine away from the passenger compartment

   B. Silence the noise of the exhaust

II. Terms and definitions (Transparency 1)

   A. Exhaust manifold--Pipe connecting the engine exhaust ports to the exhaust pipe; usually made of cast iron

   B. Exhaust pipe--Pipe connecting the exhaust manifold to the muffler

   C. Muffler--Chamber through which the exhaust gases are passed to quiet the sounds of the running engine

   D. Tail pipe--Exhaust pipe running from the muffler to the rear of the car

   E. Pipe clamp--Circular bolt used to clamp the exhaust pipe and tail pipe to the muffler

   F. Pipe hanger--Metal and fabric strap used to support the exhaust system on the vehicle

   G. Manifold heat control valve--Valve located in the exhaust manifold that deflects a certain amount of hot gas around the carburetor base to aid engine warm-up

   H. Resonator--Small mufflerlike device placed near the end of the tail pipe to provide additional silencing of the exhaust

   I. Crossover pipe--Pipe used on V-type engines to connect exhaust manifolds together to enter a single exhaust pipe

   J. Catalyst--Material whose presence alters the rate of a chemical reaction of the exhaust gases producing a combustionlike reaction

   K. Catalytic converter--Device in an automobile exhaust system which contains a catalyst and burns exhaust gases into harmless materials (Transparency 4)

INFORMATION SHEET

III. Types of mufflers (Transparency 2)

A. Reverse flow

B. Straight through

C. Chambered pipe

IV. Operation of the manifold heat control valve (Transparency 3)

A. Engine cold--Heat control valve is shut to allow exhaust gases to pass under the carburetor base to bring about better fuel atomization and warm-up

B. Engine warm--Heat control valve is open to allow exhaust gases to pass out the exhaust

V. Construction and operation of catalytic converter (Transparency 4)

A. Is constructed of stainless steel shell

B. Contains honeycombed or pelleted element coated with platinum and palladium

C. Operates by combustion reaction of a catalyst producing heat up to 1600 degrees under normal conditions

D. Uses heat shields to protect underside of car from excessive heat

(NOTE: If the engine is not operating at peak efficiency, it could cause excessive and dangerous overheating of the converter.)

E. Requires use of unleaded gasoline for fuel

F. Contains access hole for exhaust sampling, usually

VI. Tools for exhaust system service (Transparency 5)

A. Power chisel

(NOTE: The chisel is used to cut away welded or rusted exhaust system components.)

B. Hand pipe cutter

(NOTE: The cutter is used to make a clean, straight cut during exhaust system service.)

INFORMATION SHEET

C. Straightening cone

(NOTE: A crimped or distorted pipe can be made round.)

D. Pipe expanding tool

(NOTE: Pipes can be expanded for a proper fit.)

E. Chain wrench

(NOTE: The wrench provides a good grip on the pipe to aid in removal or alignment.)

F. Electric pipe joint heater

(NOTE: Heat is applied to aid in loosening exhaust system joints.)

VII. Types of exhaust systems (Transparency 6)

A. Single

1. Uses one exhaust pipe, muffler, and tail pipe
2. Requires use of a crossover pipe

B. Dual

1. Uses two separate exhaust pipes, mufflers, and tail pipes
2. Does not require use of a crossover pipe

VIII. Prevention of carbon monoxide poisoning

(NOTE: Exhaust gases contain carbon monoxide, a deadly poison.)

A. Repair leaks in an exhaust system immediately to prevent asphyxiation of the driver and passengers

B. Do not operate engines in a closed shop without adequate ventilation

(NOTE: Always use shop exhaust ventilation system.)

IX. Causes of corrosion of exhaust system

A. Internal corrosion

1. Water caused by the combustion process collects in the muffler

INFORMATION SHEET

2. Water mixing with exhaust gases creates a light acid that etches the exhaust metal

3. Corrosion is extreme during short drives because the system does not get hot enough to evaporate the water

B. External corrosion

1. Rusting occurs due to rain, snow, and humidity

2. Corrosion is accelerated by the use of salt on icy road surfaces

X. Basic components of the exhaust gas recirculating system (Transparency 7)

A. EGR control valve

B. Intake manifold ports

C. Coolant control valve

D. Exhaust transfer passage

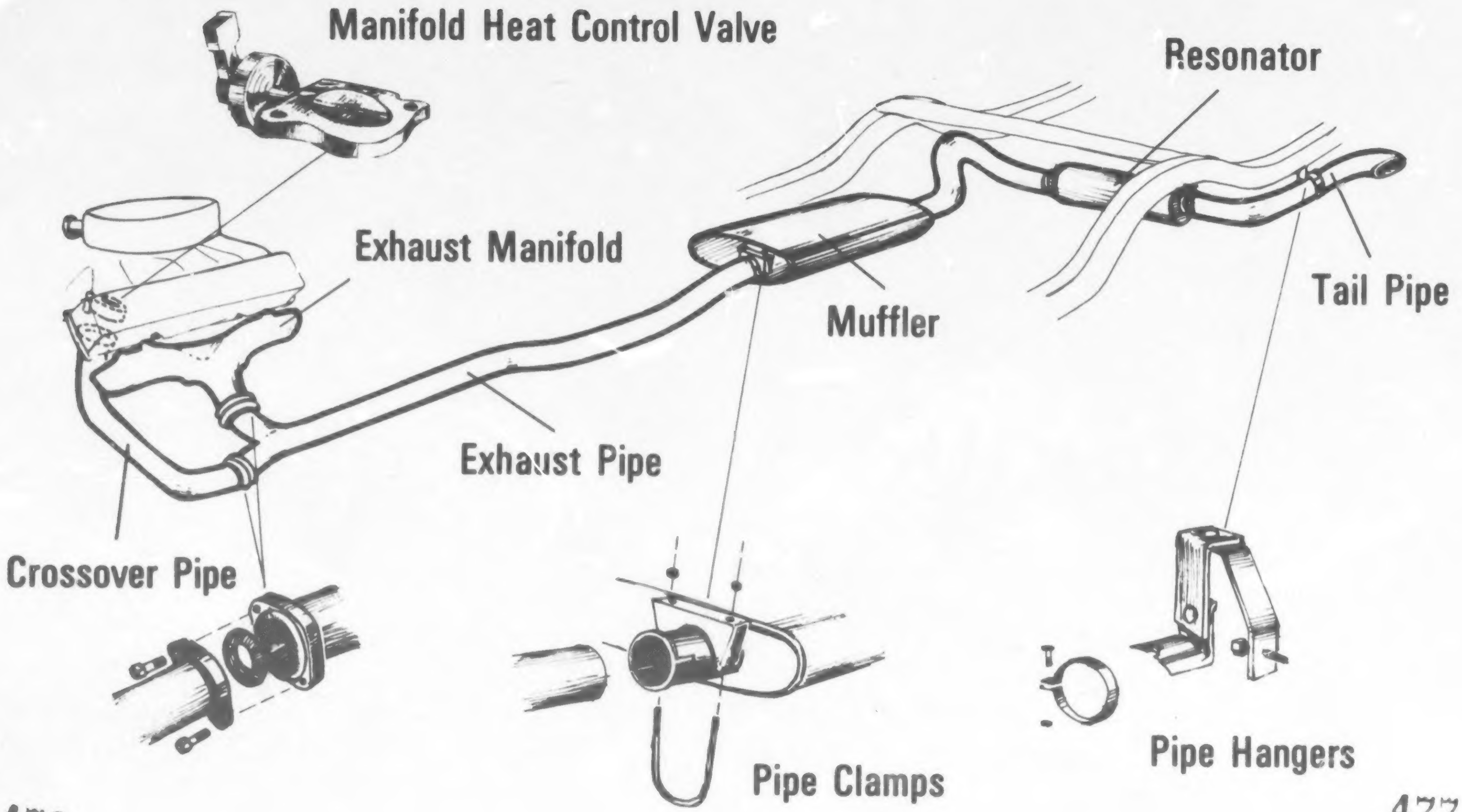
E. Vacuum source

(NOTE: EGR systems may contain other components such as vacuum amplifier, time delay solenoid, coolant control idle enrichment valve, delay timer, and ported vacuum source.)

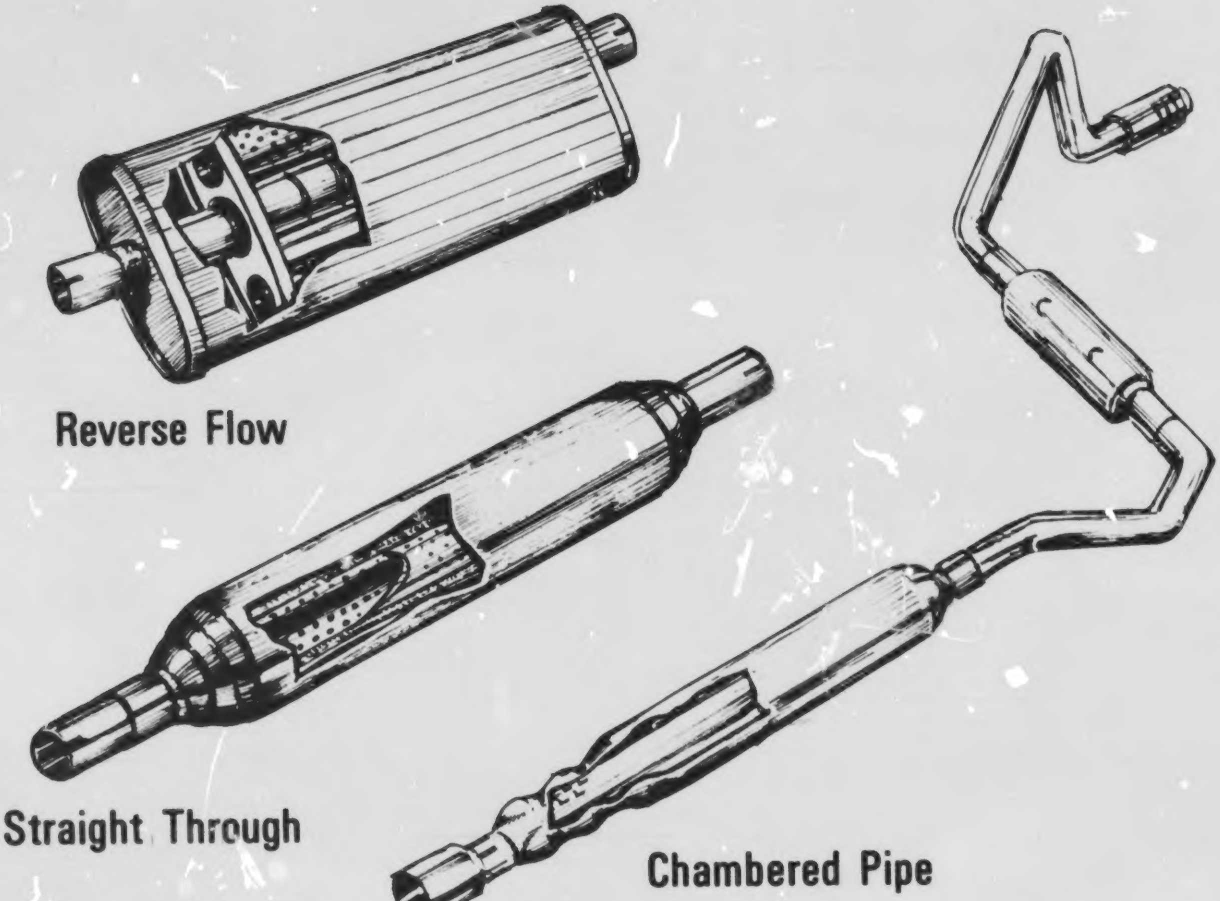
XI. Purpose of exhaust gas recirculating system--To reduce oxides of nitrogen (NOx) in engine exhaust gases by lowering peak flame temperature during combustion

(NOTE: This is accomplished by allowing a predetermined amount of hot exhaust gas to recirculate and dilute the incoming fuel-air mixture.)

Exhaust System Components


Manifold Heat Control Valve
Resonator
Exhaust Manifold
Muffler
Tail Pipe
Exhaust Pipe
Crossover Pipe
Pipe Hangers
Pipe Clamps

Types of Mufflers

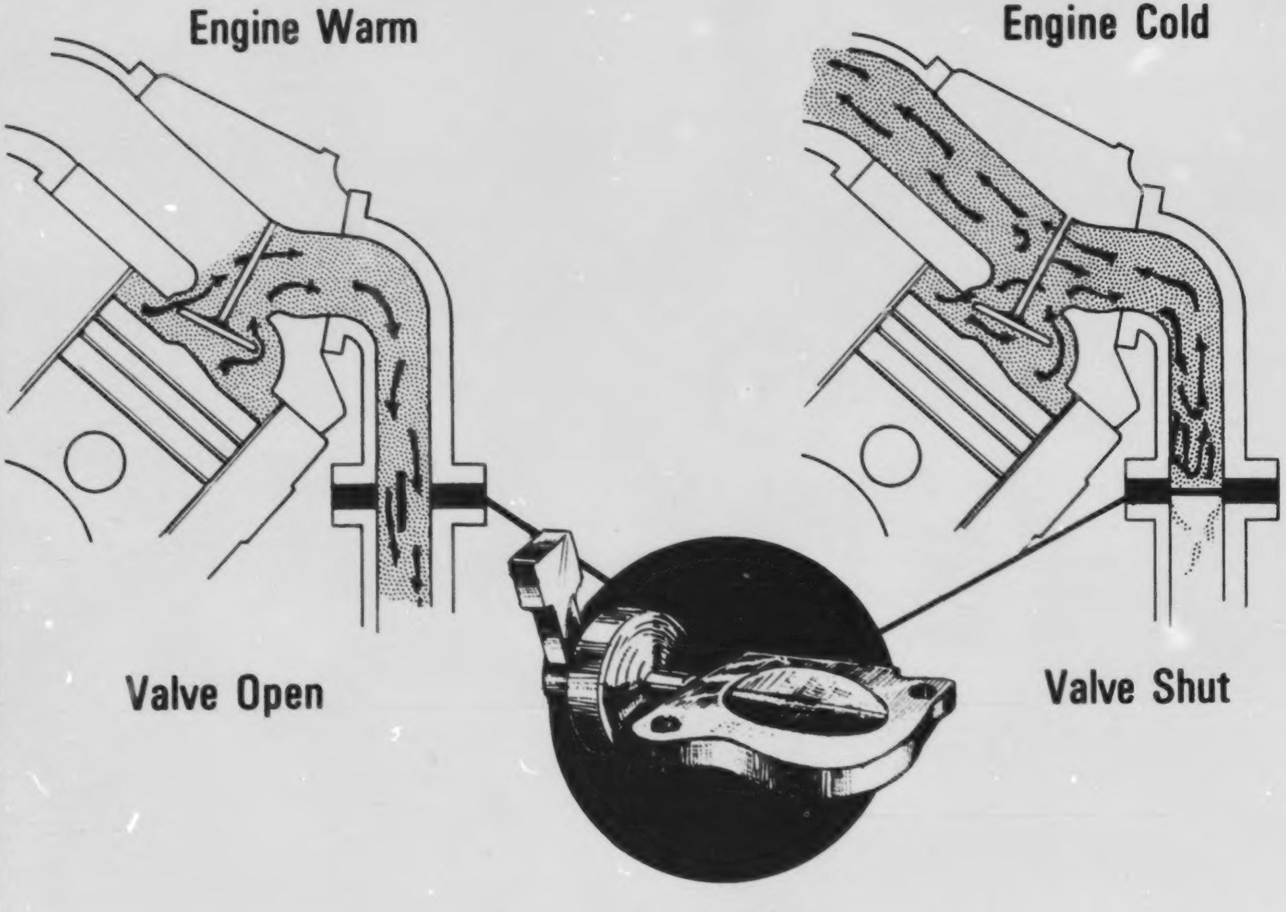


Reverse Flow

Straight Through

Chambered Pipe

Operation of Manifold Heat Control Valve



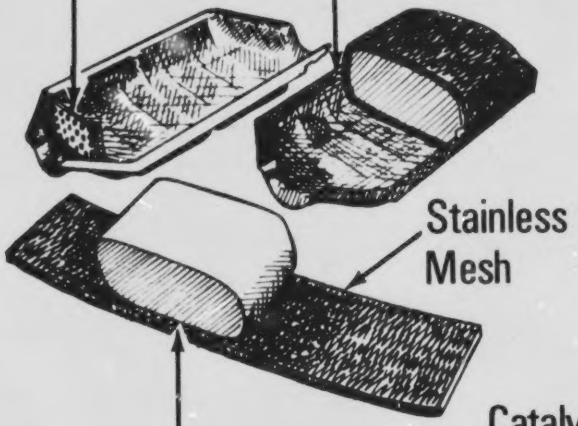
Engine Warm

Engine Cold

Valve Open

Valve Shut

Catalytic Converter and Heat Shields

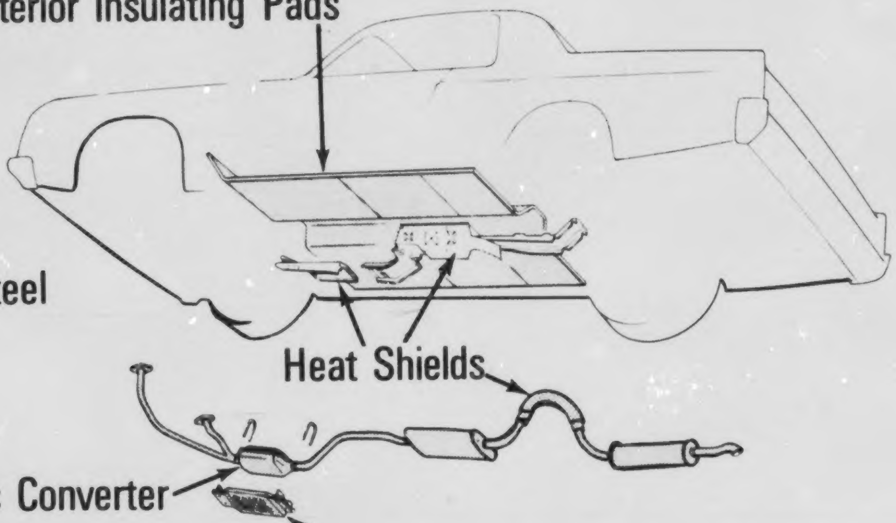


Flow Diffuser

Stainless Steel Shell

Stainless Steel Mesh

Platinum and Palladium Catalyst



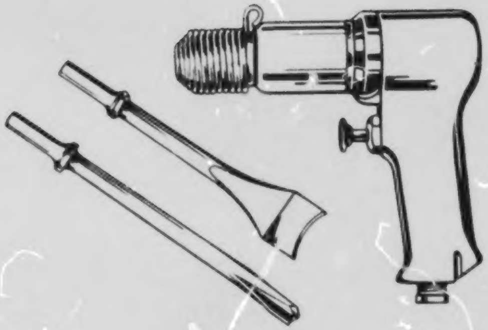
Interior Insulating Pads

Heat Shields

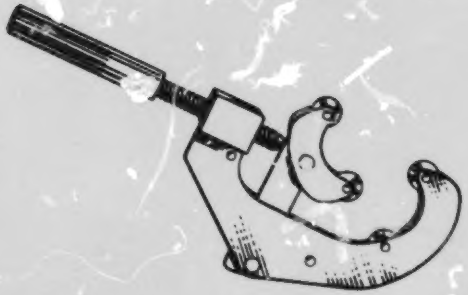
Catalytic Converter

Lower Shield

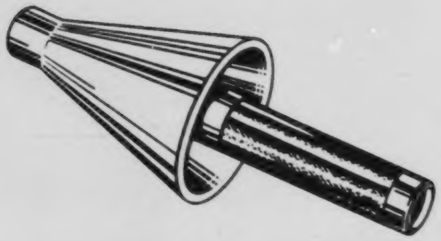
Tools for Exhaust System Service



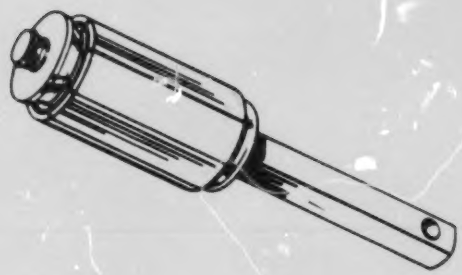
Power Chisel



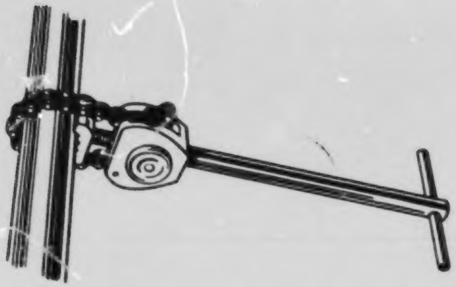
Hand Pipe Cutter



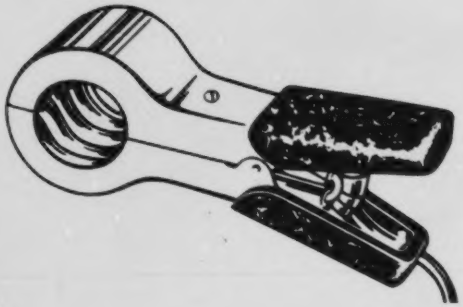
Straightening Cone



Pipe Expanding Tool

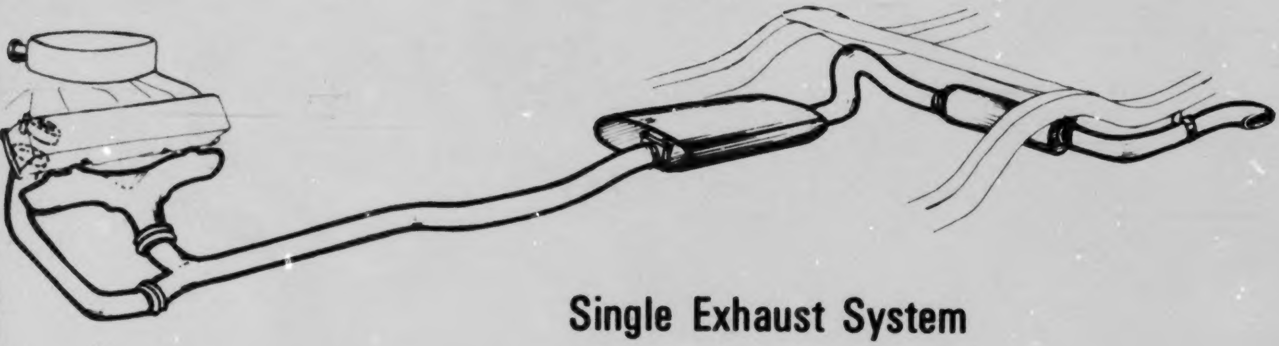


Chain Wrench

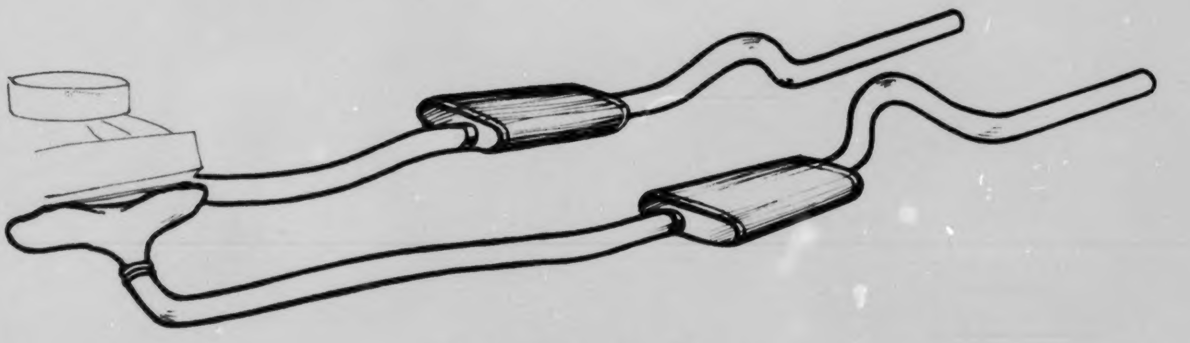


Electric Pipe Joint Heater

Types of Exhaust Systems

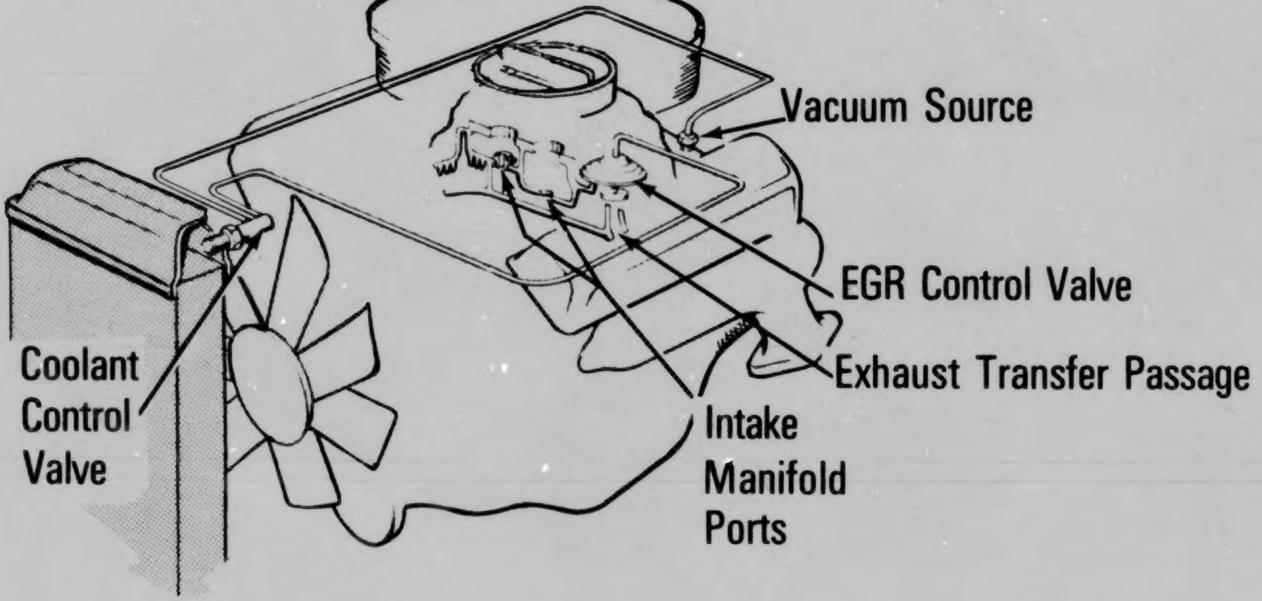


Single Exhaust System



Dual Exhaust System

Exhaust Gas Recirculation System


Vacuum Source
EGR Control Valve
Exhaust Transfer Passage
Coolant Control Valve
Intake Manifold Ports

AM I - 169-C

EXHAUST SYSTEM
UNIT IV

JOB SHEET #1--SERVICE A MANIFOLD HEAT CONTROL VALVE

I. Tools and equipment

   A. Suitable manifold heat control valve solvent

   B. Channel-lock pliers

   C. Small ball-peen hammer

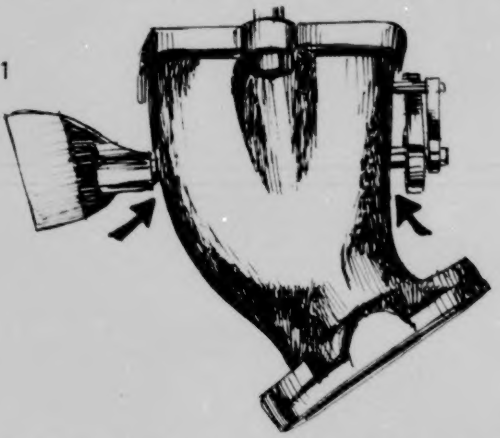
II. Procedure

   A. Locate manifold heat control valve

   (NOTE: On six-cylinder engines it is usually located in the center of the exhaust manifold under the carburetor. On V-type engines it is usually contained in the exhaust manifold or between the exhaust manifold and exhaust pipe on the right side.)

   B. Apply manifold heat control valve solvent to both ends of valve shaft (Figure 1)

FIGURE 1



   (NOTE: The manifold should be cool. Allow the solvent a few minutes to penetrate.)

   C. Work the valve back and forth until it turns freely

   (NOTE: If the valve remains stuck, tap lightly with the hammer while working the valve with the channel-lock pliers. Continue the procedure until the valve works freely.)

   D. Make sure the bi-metal spring and anti-rattle spring are in place before concluding job

EXHAUST SYSTEM
UNIT IV

JOB SHEET #2--REMOVE AND REPLACE AN EXHAUST MANIFOLD

I. Tools and equipment

   A. Floor jack

   B. Jack stands

   C. Sockets, 1/2" - 11/16" (12 mm - 18 mm), 3/8" drive

   D. Extensions, 6" and 12" (125 mm - 250 mm), 3/8" drive

   E. Ratchet, 3/8" drive

   F. Combination end wrenches, 1/2" - 3/4" (12 mm - 20 mm)

   G. Torque wrench, 1/2" drive

   H. Socket adaptor, 1/2" to 3/8"

   I. Penetrating oil

II. Procedure

   A. Lift vehicle with floor jack

   B. Support vehicle on jack stands

   C. Remove exhaust pipe flange fasteners

   (NOTE: It will be necessary to saturate the fasteners with penetrating oil. Use extra care when removing fasteners to avoid twisting off the manifold studs.)

   D. Lower exhaust pipe away from exhaust manifold

   E. Remove crossover pipe if required

   (NOTE: Use penetrating oil on fasteners. Avoid twisting off any bolts or studs securing the crossover pipe.)

   F. Remove any braces or tubing that may be connected to the exhaust manifold

   G. Remove the manifold retainer bolts

   (NOTE: Use penetrating oil on retainer bolts. Avoid twisting off any bolts or studs securing the exhaust manifold.)

JOB SHEET #2

H. Remove the exhaust manifold

(NOTE: The manifold should be checked for cracks and warpage.)

I. Clean mating surfaces of manifold with a large flat file

(NOTE: Avoid cutting extra metal from manifold surface.)

J. Install new gaskets if required

K. Attach manifold; start retainer bolts

L. Tighten retainer bolts in a sequence to avoid distortion

M. Torque retainer bolts to manufacturer's specifications

N. Replace any braces or tubing that was removed

O. Clean mating surfaces of crossover pipe if required

P. Install new gaskets if required

Q. Install crossover pipe and tighten fasteners securely if required

R. Clean mating surfaces of exhaust pipe

S. Install new gaskets if required

T. Install exhaust pipe; start fasteners

U. Check exhaust pipe alignment

(NOTE: Make sure pipe does not contact frame, fuel lines, or hydraulic lines.)

V. Torque exhaust pipe fasteners to manufacturer's specifications

W. Lower car to floor

X. Start engine

Y. Check for leaks

(NOTE: If leaks are present, repair them at once.)

EXHAUST SYSTEM
UNIT IV

JOB SHEET #3--REMOVE AND REPLACE AN EXHAUST PIPE

I. Tools and equipment

  A. Floor jack

  B. Jack stands

  C. Sockets, 1/2" - 11/16" (12 mm - 18 mm), 3/8" drive

  D. Extensions, 6" and 12" (125 mm and 250 mm), 3/8" drive

  E. Ratchet, 3/8" drive

  F. Suitable muffler joint removing tools

  G. Penetrating oil

  H. Torque wrench, 1/2" drive

  I. Socket adaptor, 1/2" to 3/8"

II. Procedure

  A. Lift vehicle with floor jack

  B. Support vehicle on jack stands

  C. Remove clamp from exhaust pipe and muffler joint

  (NOTE: Saturate the exhaust clamp fasteners and the exhaust pipe to muffler joint with penetrating oil.)

  D. Remove muffler from exhaust pipe

  (NOTE: It may be necessary to use the chain wrench and heat to aid the breaking loose of the muffler joint.)

  E. Remove exhaust pipe fasteners

  (NOTE: Saturate the exhaust pipe fasteners with penetrating oil. Use extra care when removing fasteners to avoid twisting off the manifold studs.)

  F. Remove any braces or hangers if required

  G. Remove the exhaust pipe

JOB SHEET #3

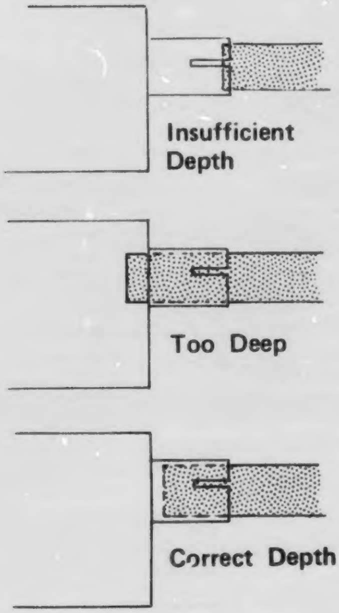
H. Clean mating surfaces of the exhaust pipe and exhaust manifold

I. Install new gasket if required

J. Install exhaust pipe; start fasteners

K. Position muffler on exhaust pipe (Figure 1)

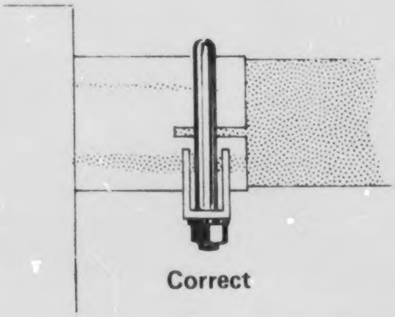
FIGURE 1


Insufficient Depth
Too Deep
Correct Depth

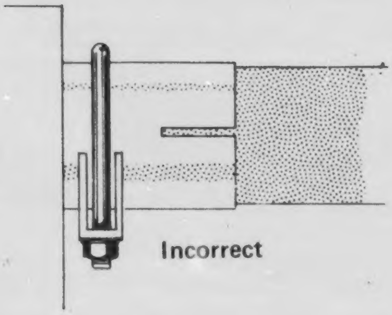
JOB SHEET #3

L. Install exhaust pipe clamp; start fasteners (Figure 2)

FIGURE 2



Correct



Incorrect

M. Align exhaust pipe and muffler

(NOTE: Make sure exhaust pipe and muffler do not contact the frame, fuel lines, or hydraulic lines.)

N. Tighten exhaust pipe retainer bolts to manufacturer's specifications

O. Tighten exhaust pipe clamp securely

P. Replace any braces or hangers that were removed

Q. Lower vehicle to floor

R. Start engine

S. Check for leaks

(CAUTION: If leaks are present, repair them at once.)

EXHAUST SYSTEM
UNIT IV

JOB SHEET #4--REMOVE AND REPLACE A MUFFLER

I. Tools and equipment

  A. Floor jack

  B. Jack stands

  C. Sockets (preferably deep sockets), 1/2" - 5/8" (12 mm - 16 mm), 3/8" drive

  D. Extensions, 6" (125 mm), 3/8" drive

  E. Ratchet, 3/8" drive

  F. Suitable muffler joint removing tools

  G. Penetrating oil

II. Procedure

  A. Lift vehicle with floor jack

  B. Support vehicle on jack stands

  C. Remove clamp at outlet end of muffler or exhaust hanger if necessary

  (NOTE: Apply penetrating oil to muffler joints and exhaust clamps.)

  D. Remove tail pipe from muffler

  (NOTE: It may be necessary to use the chain wrench and heat to free the tail pipe from the muffler.)

  E. Remove clamp at inlet end of muffler

  (NOTE: Some mufflers are welded to the exhaust pipe and will have to be cut off.)

  F. Remove muffler from exhaust pipe

  (NOTE: Use penetrating oil, tapping, and heat if necessary to free the muffler joint.)

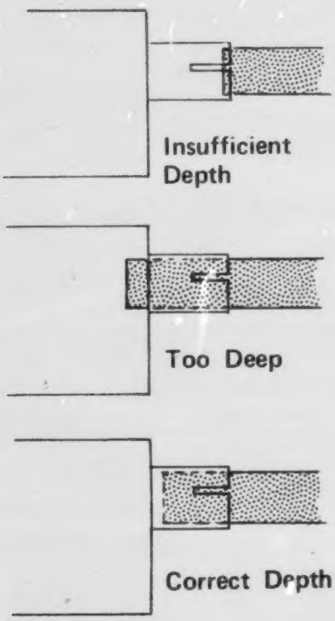
  G. Clean and straighten exhaust pipe and tail pipe if required

JOB SHEET #4

H. Replace muffler

1. Slide muffler onto exhaust pipe
2. Slide tail pipe into muffler (Figure 1)

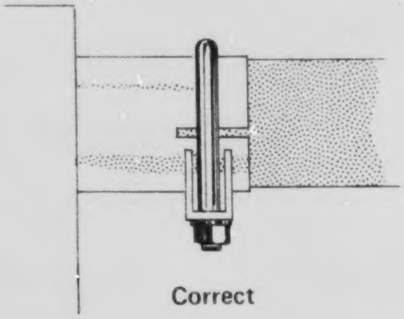
FIGURE 1


Insufficient Depth
Too Deep
Correct Depth

JOB SHEET #4

I. Place and start fasteners on clamps (Figure 2)

FIGURE 2



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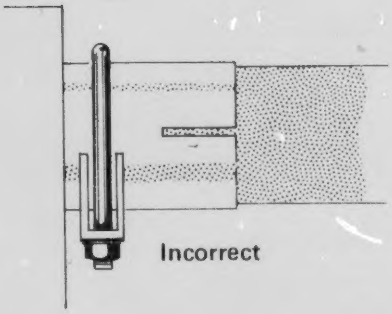


Incorrect

J. Position muffler on pipes and tighten clamps slightly

K. Recheck position of muffler and alignment of exhaust system

(NOTE: Make sure the exhaust pipe, muffler, and tail pipe do not contact the frame, fuel lines, or hydraulic lines.)

L. Tighten exhaust clamps securely

(NOTE: Inspect all clamps and hangers to determine if replacement is necessary.)

M. Lower car to floor

N. Start engine

O. Check for exhaust leaks

(CAUTION: If leaks are present, repair them at once.)

EXHAUST SYSTEM
UNIT IV

JOB SHEET #5--REMOVE AND REPLACE A CATALYTIC CONVERTER

I. Tools and equipment

   A. Floor jack

   B. Jack stands

   C. Sockets, 1/2" - 11/16" (12 mm - 18 mm), 3/8" drive

   D. Extensions, 6" and 12" (125 mm and 250 mm), 3/8" drive

   E. Ratchet, 3/8" drive

   F. Combination end wrenches, 1/2" - 3/4" (12 mm - 20 mm)

   G Torque wrench, 1/2" drive

   H. Socket adaptor, 1/2" to 3/8"

   I. Penetrating oil

II. Procedure

   (CAUTION: Be sure converter has cooled before handling.)

   A. Lift vehicle with floor jack

   B. Support vehicle on jack stands

   C. Remove heat shields from catalytic converter

   D. Remove converter inlet and outlet flange attaching nuts

      (NOTE: Apply penetrating oil on fasteners. Avoid twisting off any bolts.)

   E. Move the muffler/tailpipe assembly rearward until converter can be removed

   F. Replace catalytic converter

   G. Clean mating surfaces

   H. Install new gaskets

JOB SHEET #5

I. Move muffler/tailpipe assembly forward until attaching surfaces are correctly aligned

J. Install converter inlet and outlet flange attaching nuts and tighten securely

K. Install heat shields

L. Lower car to floor

M. Start engine

N. Check for exhaust leaks

(CAUTION: If leaks are present, repair them at once.)

EXHAUST SYSTEM
UNIT IV

JOB SHEET #6--REMOVE AND REPLACE A TAIL PIPE

I. Tools and equipment

   A. Floor jack

   B. Jack stands

   C. Sockets (preferably deep sockets), 1/2" - 5/8" (12 mm - 16 mm), 3/8" drive

   D. Extensions, 6" (125 mm), 3/8" drive

   E. Ratchet, 3/8" drive

   F. Suitable muffler joint removing tools

   G. Penetrating oil

   H. Combination end wrenches, 1/2" - 5/8" (12 mm - 16 mm)

II. Procedure

   A. Lift vehicle with floor jack

   B. Support vehicle on jack stands

   (NOTE: It will be necessary to place the rear jack stands on the frame. This will allow the rear axle assembly to be lowered, thus providing room for tail pipe removal.)

   C. Remove tail pipe hangers

   (NOTE: Saturate outlet muffler joint, clamps, and hanger fasteners with penetrating oil.)

   D. Remove tail pipe clamp

   E. Remove tail pipe from muffler

   (NOTE: Use the chain wrench, tapping, and heat if necessary to free the tail pipe joint.)

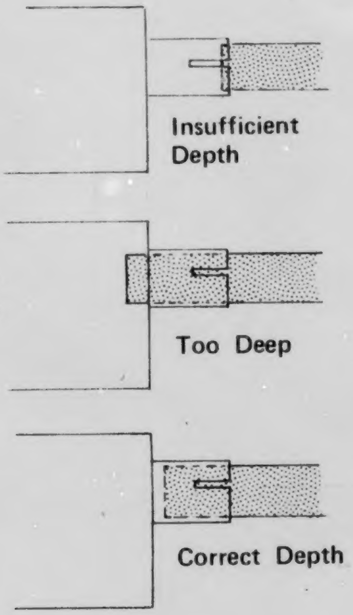
   F. Clean and straighten the muffler outlet

JOB SHEET #6

G. Replace tail pipe

1. Slide tail pipe into place
2. Attach tail pipe to muffler (Figure 1)

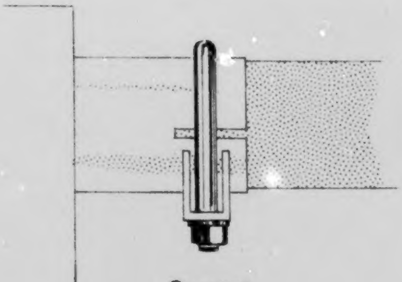
FIGURE 1


Insufficient Depth
Too Deep
Correct Depth

JOB SHEET #6

H. Replace clamps and hangers (Figure 2)

FIGURE 2



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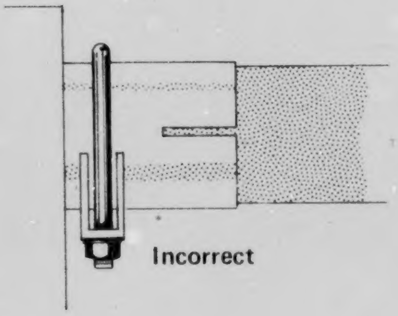


Incorrect

I. Start fasteners on clamps and hangers

J. Position tail pipe and tighten clamps slightly

K. Recheck position of tail pipe and alignment of exhaust system

(NOTE: Make sure the exhaust pipe, muffler, and tail pipe do not contact the frame, fuel lines, hydraulic lines, or any body parts.)

L. Tighten all clamps and hangers securely

M. Lower vehicle to floor

N. Start engine

O. Check for exhaust leaks

(CAUTION: If leaks are present, repair them at once.)

EXHAUST SYSTEM
UNIT IV

TEST

1. Write the two purposes of the exhaust system.

a.

b.

2. Match the terms on the right to the correct definitions.

_____a. Circular bolt used to clamp the exhaust pipe and tail pipe to the muffler

_____b. Pipe connecting the engine exhaust ports to the exhaust pipe; usually made of cast iron

_____c. Valve located in the exhaust manifold that deflects a certain amount of hot gas around the carburetor base to aid engine warm-up

_____d. Metal and fabric strap used to support the exhaust system on the vehicle

_____e. Material whose presence alters the rate of a chemical reaction of the exhaust gases producing a combustionlike reaction

_____f. Chamber through which the exhaust gases are passed to quiet the sounds of the running engine

_____g. Pipe connecting the exhaust manifold to the muffler

_____h. Device in an automobile exhaust system which contains a catalyst and burns exhaust gases into harmless materials

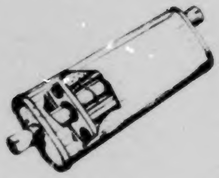
_____i. Pipe used on V-type engines to connect exhaust manifolds together to enter a single exhaust pipe

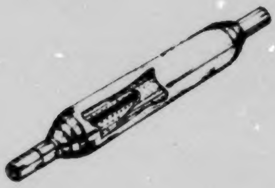
1. Exhaust manifold
2. Exhaust pipe
3. Muffler
4. Tail pipe
5. Pipe clamp
6. Pipe hanger
7. Manifold heat control valve
8. Resonator
9. Crossover pipe
10. Catalyst
11. Catalytic converter

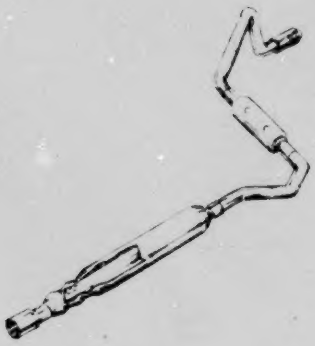
______ j. Small mufflerlike device placed near the end of the tail pipe to provide additional silencing of the exhaust

______ k. Exhaust pipe running from the muffler to the rear of the car

3. Identify the following types of mufflers.







a. ____________ b. ____________ c. ____________

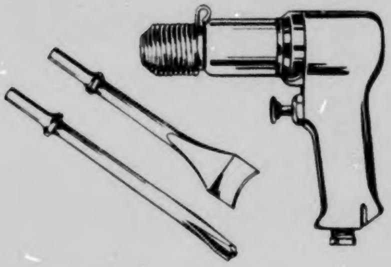
4. Describe the operation of the manifold heat control valve.

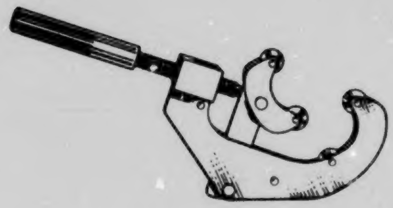
   a. Engine cold--

   b. Engine warm--

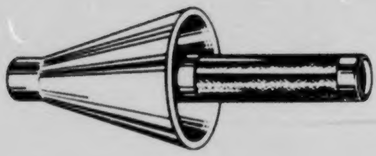
5. Describe the construction and operation of a catalytic converter.

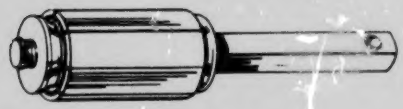
6. Identify the following tools used for exhaust system service.



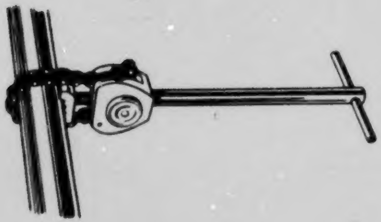


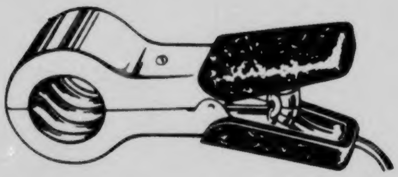
a. ____________________ b. ____________________





c. ____________________ d. ____________________





e. ____________________ f. ____________________

7. Distinguish between the types of exhaust systems by placing an "S" in front of the description of a single type and a "D" in front of the dual type exhaust system.

   ______a. Uses one exhaust pipe, muffler, and tail pipe; requires use of a crossover pipe

   ______b. Uses two separate exhaust pipes, mufflers, and tail pipes; does not require use of a crossover pipe

8. List two safety precautions for preventing carbon monoxide poisoning.

   a.

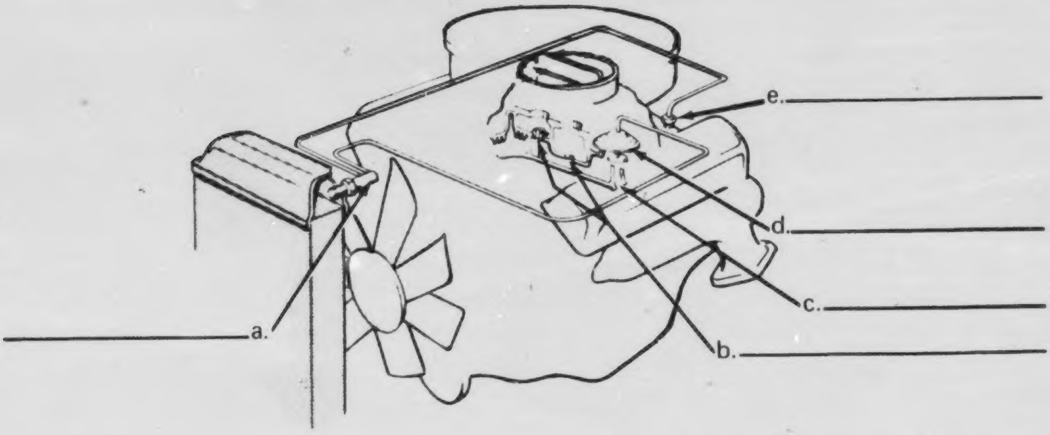
   b.

9. Discuss the causes of internal and external corrosion of the exhaust system.

   a. Internal corrosion

   b. External corrosion

10. Identify the basic components of the exhaust gas recirculation system in the diagram below.



11. Discuss the purpose of the exhaust gas recirculating system.

12. Demonstrate the ability to:

   a. Service a manifold heat control valve.

   b. Remove and replace an exhaust manifold.

   c. Remove and replace an exhaust pipe.

   d. Remove and replace a muffler.

   e. Remove and replace a catalytic converter and its heat shields.

   f. Remove and replace a tail pipe.

   (NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

EXHAUST SYSTEM
UNIT IV

ANSWERS TO TEST

1. a. Conduct the burned gases from the engine away from the passenger compartment

   b. Silence the noise of the exhaust

2. a. 5

   b. 1

   c. 7

   d. 6

   e. 10

   f. 3

   g. 2

   h. 11

   i. 9

   j. 8

   k. 4

3. a. Reverse flow

   b. Straight through

   c. Chambered pipe

4. Description should include:

   a. Engine cold--Heat control valve is shut to allow exhaust gases to pass under the carburetor base to bring about better fuel atomization and warm-up

   b. Engine warm--Heat control valve is open to allow exhaust gases to pass out the exhaust

5. Description should include:

   a. Is constructed of stainless steel shell

   b. Contains honeycombed or pelleted element coated with platinum and palladium

   c. Operates by combustion reaction of a catalyst producing heat up to 1600 degrees under normal conditions

   d. Uses heat shields to protect underside of car from excessive heat

e. Requires use of unleaded gasoline for fuel

f. Contains access hole for exhaust sampling, usually

6. a. Power chisel

   b. Hand pipe cutter

   c. Straightening cone

   d. Pipe expanding tool

   e. Chain wrench

   f. Electric pipe joint heater

7. a. Single

   b. Dual

8. a. Repair leaks in an exhaust system immediately to prevent asphyxiation of the driver and passengers

   b. Do not operate engines in a closed shop without adequate ventilation

9. Discussion should include:

   a. Internal corrosion

      1) Water caused by the combustion process collects in the muffler

      2) Water mixing with exhaust gases creates a light acid that etches the exhaust metal

      3) Corrosion is extreme during short drives because the system does not get hot enough to evaporate the water

   b. External corrosion

      1) Rusting occurs due to rain, snow, and humidity

      2) Corrosion is accelerated by the use of salt on icy road surfaces

10. a. Coolant control valve

    b. Intake manifold ports

    c. Exhaust transfer passage

  d. EGR control valve

  e. Vacuum source

11. Discussion should include that the purpose of the exhaust gas recirculating system is to reduce oxides of nitrogen (NOx) in engine exhaust gases by lowering peak flame temperature during combustion

12. Performance skills evaluated to the satisfaction of the instructor

FUEL SYSTEM
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the components and write the purpose of the fuel system. The student should be able to service the fuel system. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Write the purpose of the fuel system.
2. Define terms associated with the fuel system.
3. List the purpose of each of the components of the fuel system.
4. Describe the fuel pump operation during the inlet and outlet strokes.
5. Identify types of fuel filters.
6. Identify types of air cleaners.
7. Identify parts of the carburetor.
8. Match the carburetor systems with the correct use.
9. Match gasoline additives to the correct purposes.
10. Discuss fuel injection.
11. List the variations of fuel injection systems.
12. Demonstrate the ability to:
    a. Volume and pressure test a fuel pump.
    b. Remove and replace a fuel pump.
    c. Service an air cleaner.
    d. Remove and replace a carburetor.
    e. Disassemble, adjust, and reassemble a carburetor.

FUEL SYSTEM
UNIT V

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Demonstrate and discuss procedures outlined in the job sheets.

  G. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Demonstrate the ability to accomplish the procedures outlined in the job sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Fuel System Terms

    2. TM 2--Components of the Fuel System

    3. TM 3--Fuel Pump Operation

    4. TM 4--Types of Fuel Filters

    5. TM 5--Types of Air Cleaners

6. TM 6--Parts of the Carburetor
7. TM 7--Float System
8. TM 8--Idle System
9. TM 9--Main Metering System
10. TM 10--Power System
11. TM 11--Accelerator Pump System
12. TM 12--Choke System
13. TM 13--Electronic Fuel Injection
14. TM 14--Mechanical Fuel Injection
15. TM 15--Variations of Fuel Injection Systems

D. Job sheets

1. Job Sheet #1--Volume and Pressure Test a Fuel Pump
2. Job Sheet #2--Remove and Replace a Fuel Pump
3. Job Sheet #3--Service an Air Cleaner
4. Job Sheet #4--Remove and Replace a Carburetor
5. Job Sheet #5--Disassemble, Adjust, and Reassemble a Carburetor

E. Test

F. Answers to test

II. References:

A. Stockel, Martin W. *Auto Service and Repair*. Homewood, Illinois: The Goodheart-Willcox Co., Inc., 1969.

B. Stockel, Martin W. *Auto Mechanics Fundamentals*. South Holland, Illinois: Goodheart-Willcox Co., 1969.

C. Crouse, William H. *Automotive Mechanics*. 7th ed. New York: McGraw-Hill Book Co., 1975.

D. *Basic Carburetor Manual*. Bulletin 9D-1. Rochester, New York: Rochester Products/Division of General Motors, March 1964.

E. *Oldsmobile Chassis Service Manual*. Lansing, Michigan: Oldsmobile Div./General Motors Corp., 1972.

F. *Fuels, Lubricants and Coolants*. Fundamentals of Service series. Moline: Illinois: Deere and Co., 1970.

FUEL SYSTEM
UNIT V

INFORMATION SHEET

I. Purpose of the fuel system--To supply a combustible mixture of air and fuel to the engine cylinders to meet all driving conditions

II. Terms and definitions (Transparency 1)

- A. Atomization--The breaking of a liquid into tiny particles or globules to aid evaporation
- B. Venturi--Restriction in the carburetor which makes the air speed up, causing a high vacuum
- C. Metering--Correct proportions of fuel and air for good combustion

III. Components of the fuel system and their purposes (Transparency 2)

- A. Fuel tank--Stores fuel for engine use
- B. Fuel filter--Prevents dirt and foreign matter from entering the carburetor
- C. Fuel pump--Pumps fuel from the fuel tank to the carburetor
- D. Carburetor--Mixes fuel and air in the proper proportion for a combustible mixture
- E. Fuel line--Carries fuel from the fuel tank to the carburetor
- F. Air cleaner--Filters grit and dust from the air entering the carburetor

IV. Fuel pump operation (Transparency 3)

- A. Inlet stroke
  - 1. Diaphragm flexs downward, forming a vacuum
  - 2. Inlet check valve opens
  - 3. Fuel is drawn into pump
- B. Outlet stroke
  - 1. Diaphragm is pushed upward by return spring
  - 2. Inlet valve is forced shut

INFORMATION SHEET

   3. Outlet valve is forced open

   4. Fuel is forced out of pump

V. Types of fuel filters (Transparency 4)

   A. In-line

   B. Bowl

   C. Disposable element

   D. Carburetor inlet

VI. Types of air cleaners (Transparency 5)

   A. Oil bath

   B. Paper element

   C. Polyurethane

VII. Parts of the carburetor (Transparency 6)

   A. Air horn

   B. Choke valve

   C. Needle valve assembly

   D. Float

   E. Float bowl

   F. Venturi

   G. Throttle body

   H. Throttle valve

   I. Venturi cluster

   J. Jet

   K. Nozzle

INFORMATION SHEET

VIII. Carburetor systems and their uses

- A. Float system--Maintains a given depth of fuel in the float bowl (Transparency 7)
- B. Idle system--Provides fuel delivery during closed or nearly closed throttle (Transparency 8)
- C. Main metering system--Provides fuel delivery during operation with the throttle partly to fully opened (Transparency 9)
- D. Power system--Provides extra fuel for maximum engine power to supplement the main metering system (Transparency 10)
- E. Accelerator pump system--Temporarily provides extra fuel necessary to overcome the leanness caused by rapid throttle opening (Transparency 11)
- F. Choke system--Provides a richer mixture for cold engine starting and operation (Transparency 12)

IX. Gasoline additives and their purposes

- A. Antiknock compound--Prevents pre-ignition
- B. Deposit modifier additive--Combats surface ignition and spark plug fouling
- C. Antioxident additive--Prevents gum formation during the normal life of the fuel
- D. Antirust additive--Prevents rust and corrosion in storage tanks, lines, and fuel systems
- E. Anti-icing agent--Prevents formation of ice in storage tanks, lines, and fuel systems
- F. Carburetor detergent--Prevents lead deposits from accumulating on inside of carburetor
- G. Dye
    - 1. Indicates presence of antiknocks
    - 2. Identifies various makes or grades of gasoline

X. Fuel injection--Fuel is injected under pressure directly into cylinder or into intake air flow instead of mixing with air at carburetor prior to distribution

(NOTE: There is no single type of fuel injection system.)

INFORMATION SHEET

XI. Variations of fuel injection systems (Transparencies 13, 14, and 15)

A. Mechanical

(NOTE: Metering of the fuel is controlled by mechanical devices.)

Examples: Cams, levers, gears

B. Electronic

(NOTE: Metering of the fuel is controlled by electrical devices.)

Examples: Solenoids, resistors, reostats

C. Combustion chamber injection

(NOTE: Fuel under high pressure is injected directly into combustion chamber. This system is used primarily on diesel engines and not gasoline engines.)

D. Port injection

(NOTE: Fuel under high pressure is injected into intake air flow before intake valve. This system is most common on gasoline engines.)

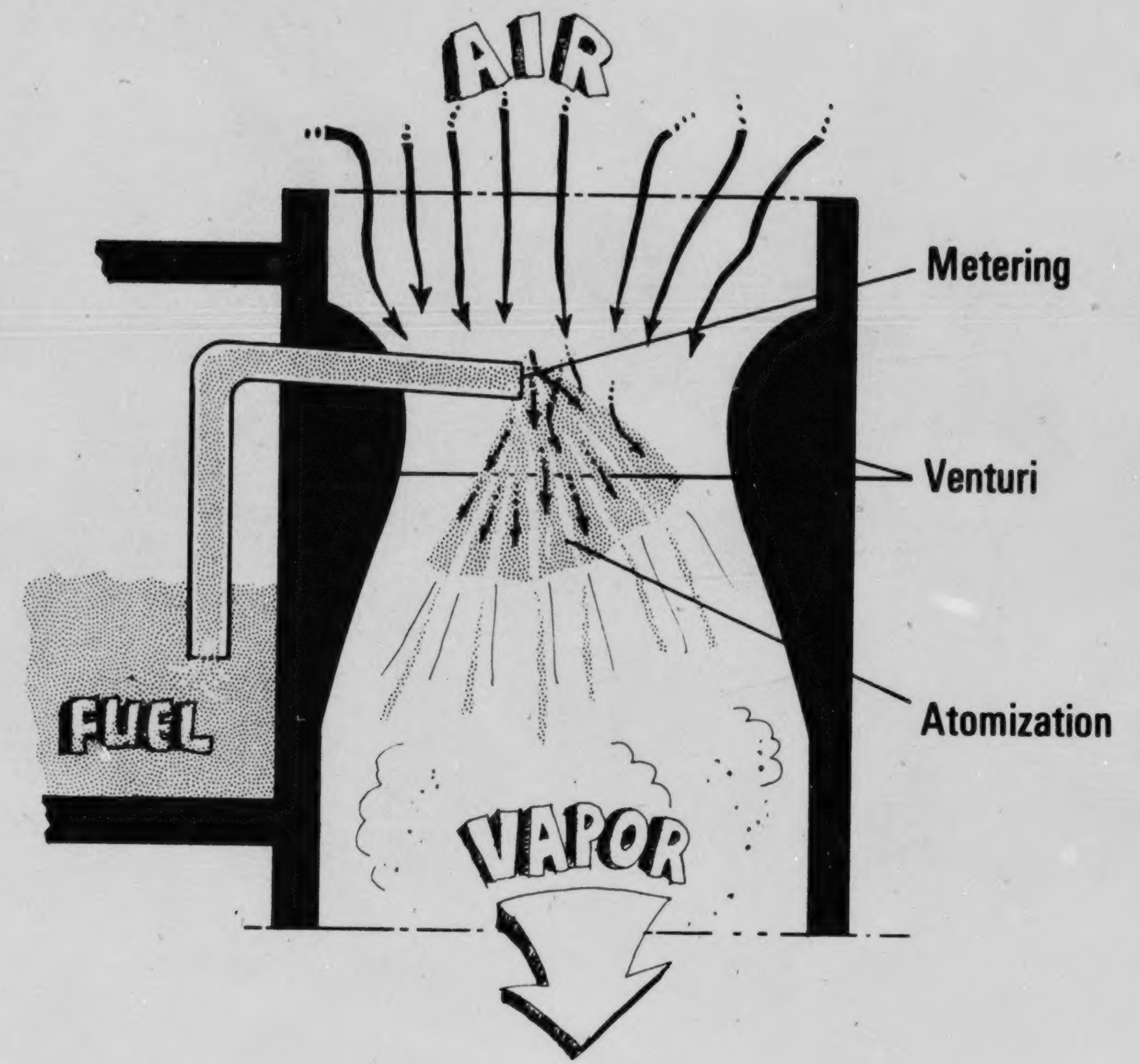
E. Constant flow injection

(NOTE: Fuel is metered into air flow at all times. Volume of fuel is varied as engine speed and load change.)

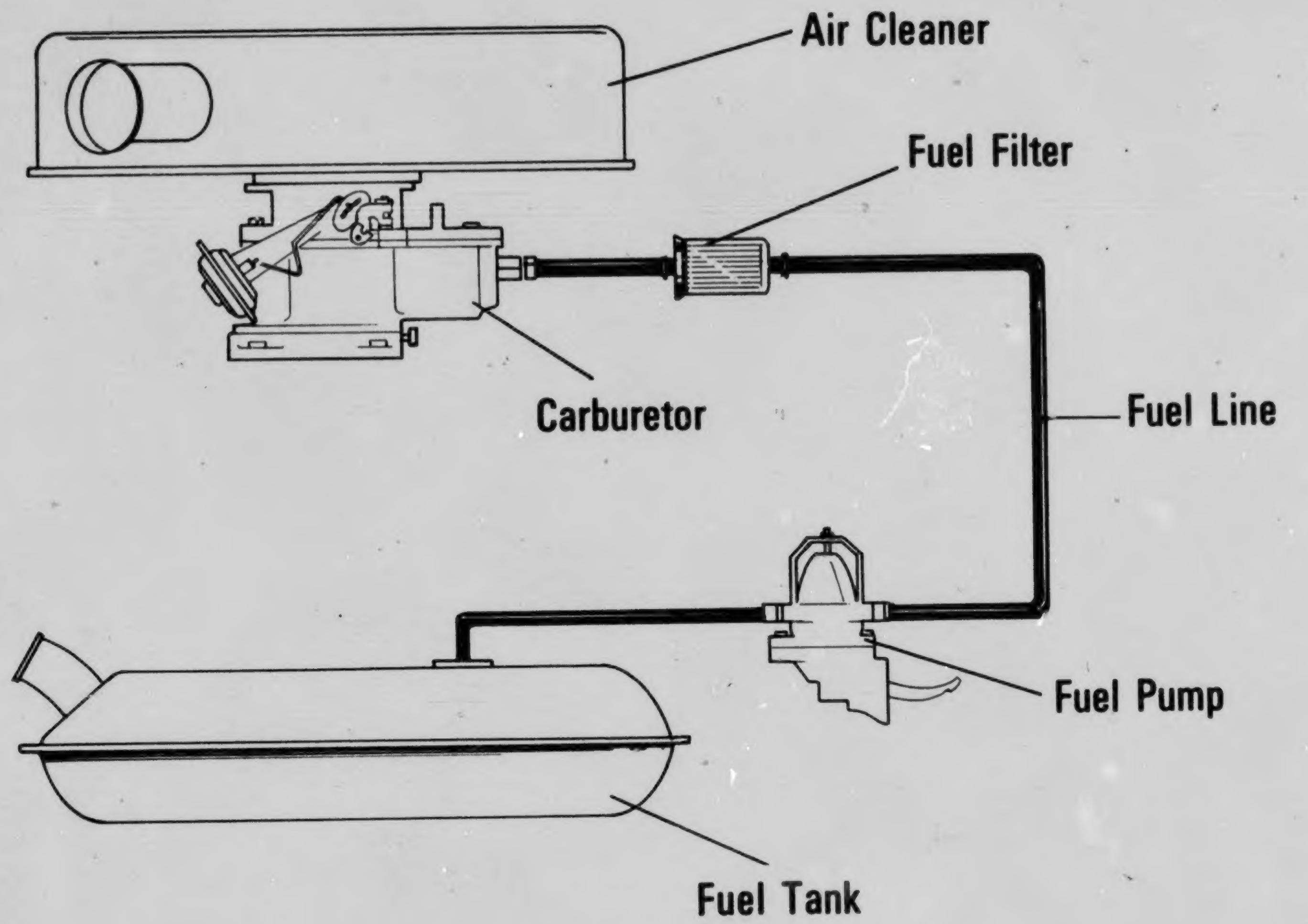
F. Timed injection

(NOTE: Fuel is metered into air flow at specific times in engine cycle as needed. Length of time injector is open is varied to adjust volume of fuel as engine speed and load change.)

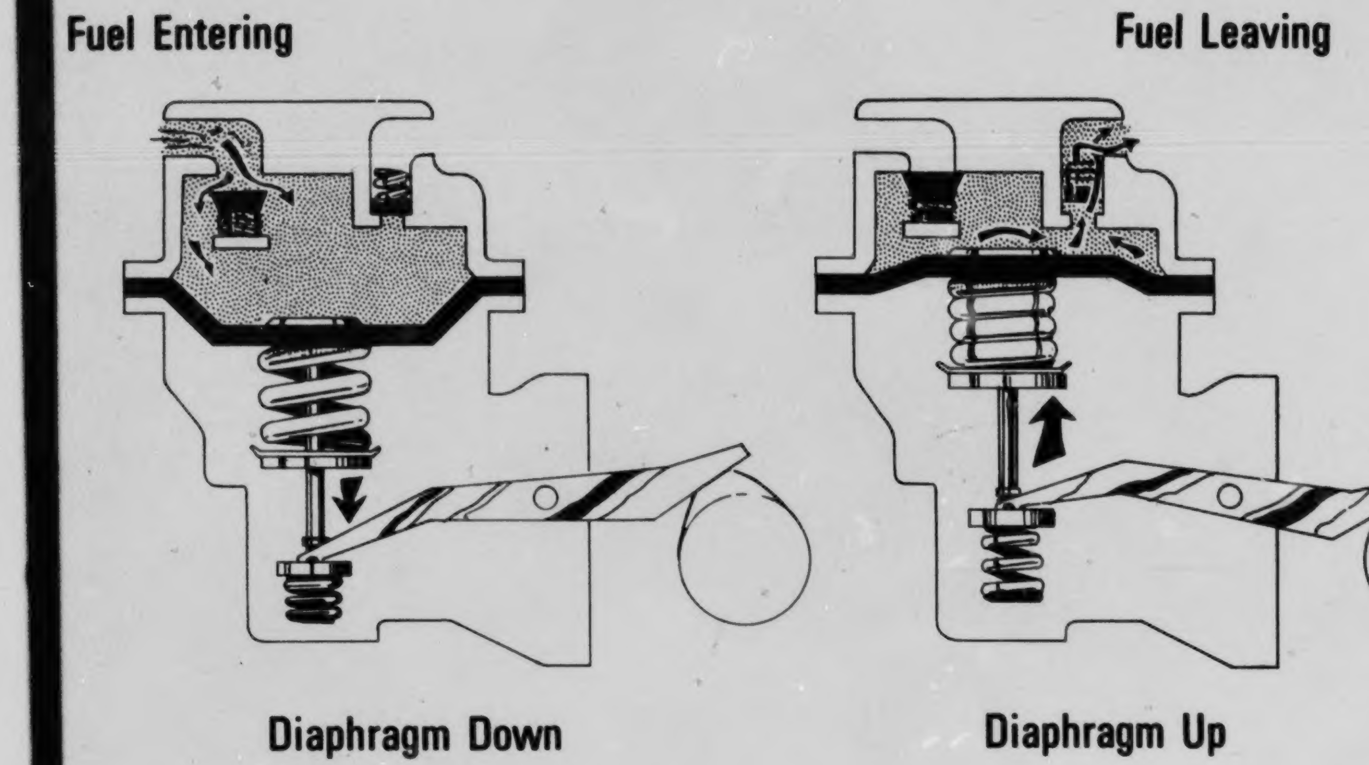
Fuel System Terms


AIR
Metering
Venturi
Atomization
FUEL
VAPOR

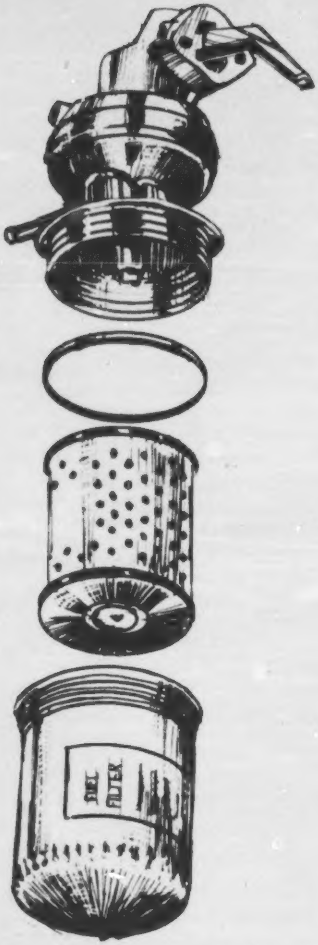
Components of the Fuel System


Air Cleaner
Fuel Filter
Carburetor
Fuel Line
Fuel Pump
Fuel Tank

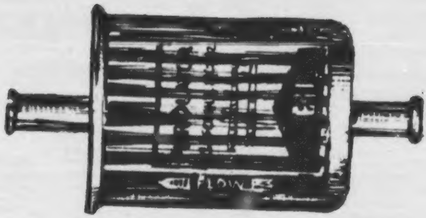
Fuel Pump Operation


Fuel Entering
Fuel Leaving
Diaphragm Down
Diaphragm Up

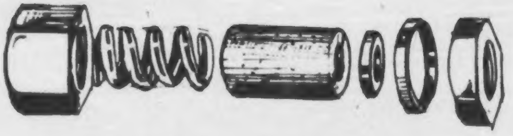
Types of Fuel Filters


FUEL FILTER

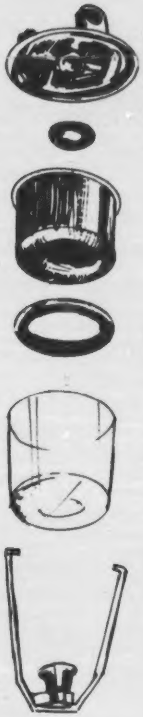
Disposable Element



In-Line

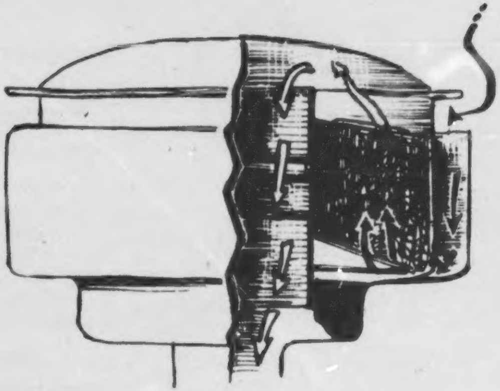


Carburetor Inlet

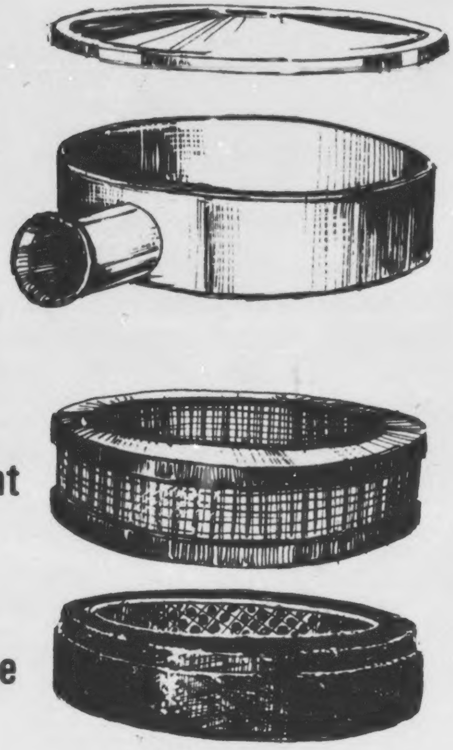


Bowl

Types of Air Cleaners



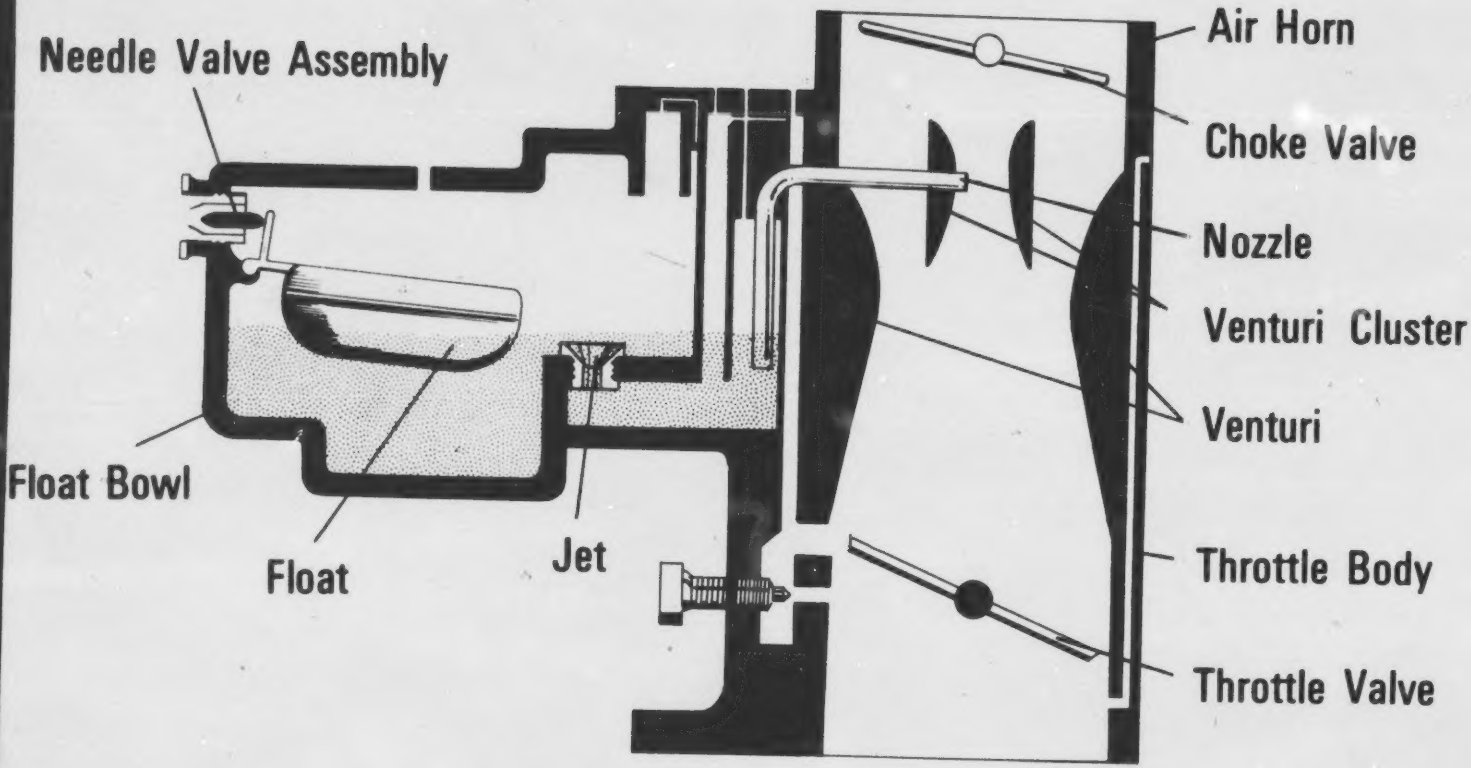
Oil Bath



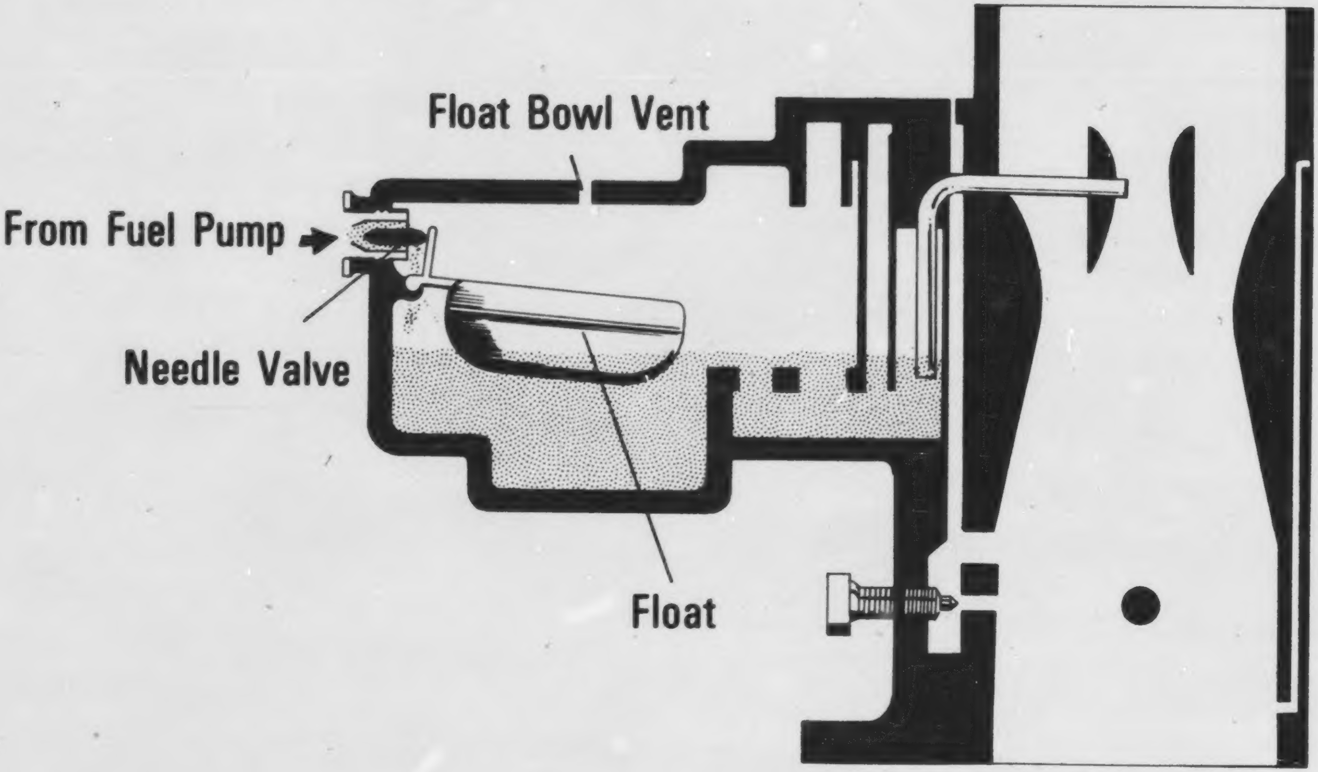
Paper Element

Polyurethane

Parts of the Carburetor

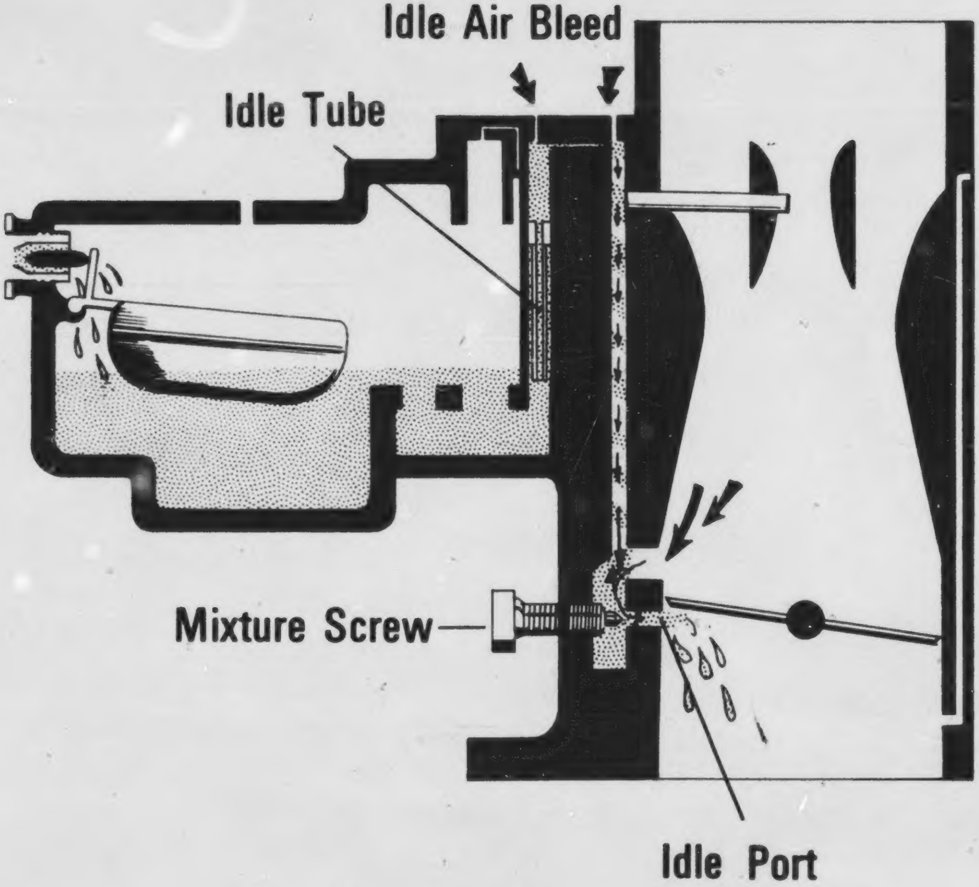

Needle Valve Assembly
Air Horn
Choke Valve
Nozzle
Venturi Cluster
Venturi
Float Bowl
Float
Jet
Throttle Body
Throttle Valve

Float System

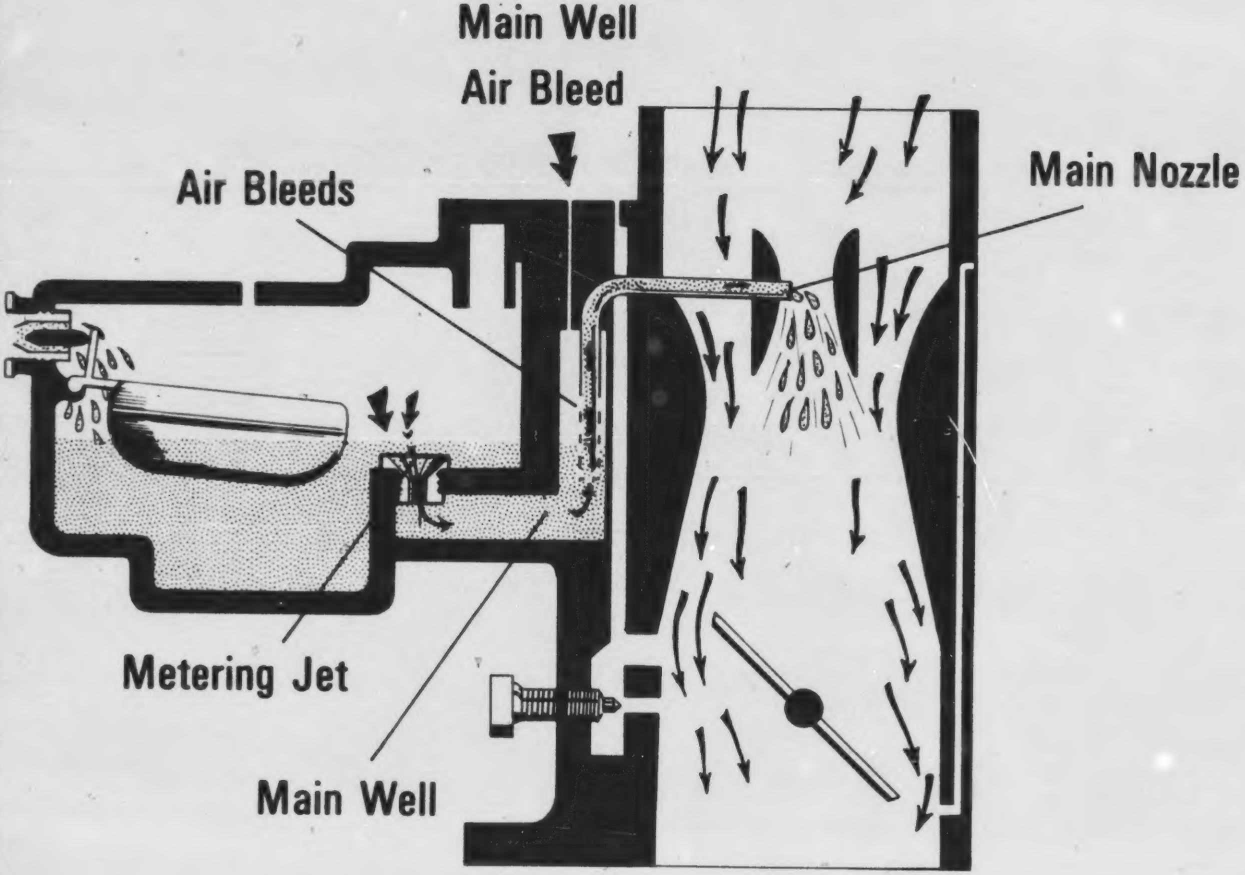

Float Bowl Vent
From Fuel Pump
Needle Valve
Float

AM I - 219-C

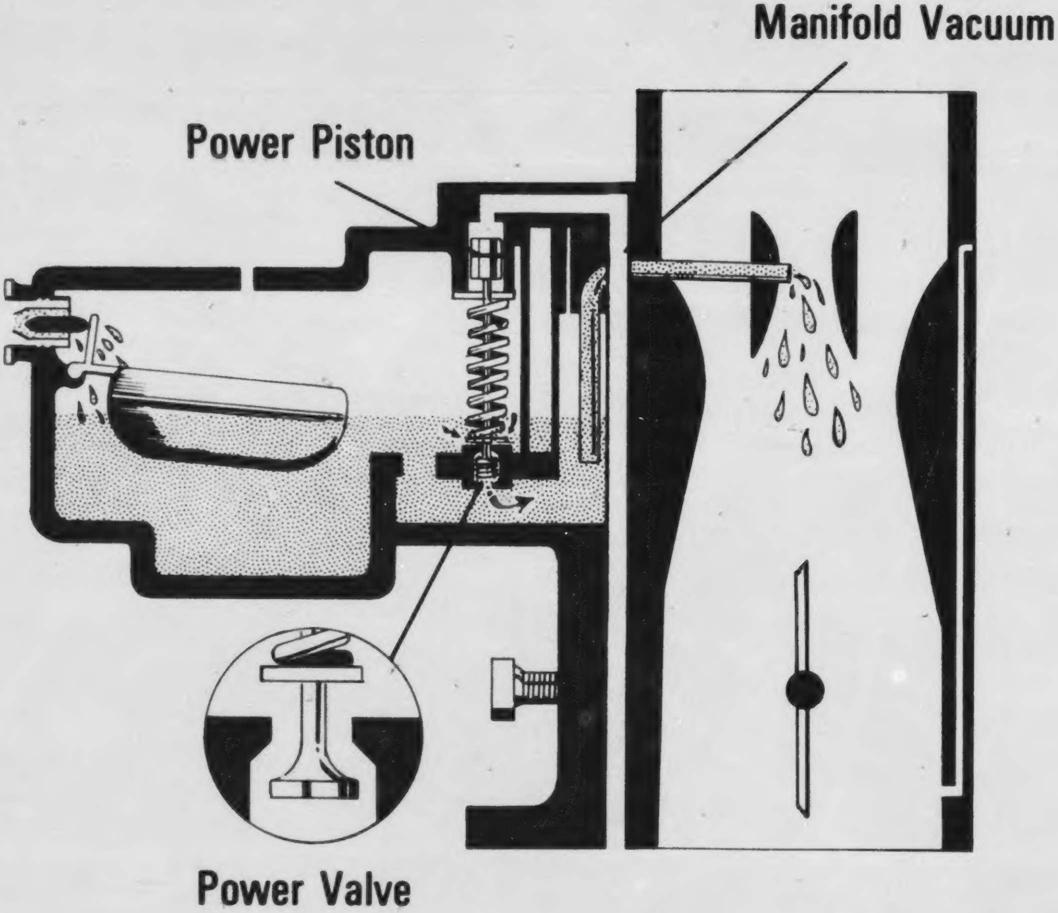
Idle System


Idle Air Bleed
Idle Tube
Mixture Screw
Idle Port

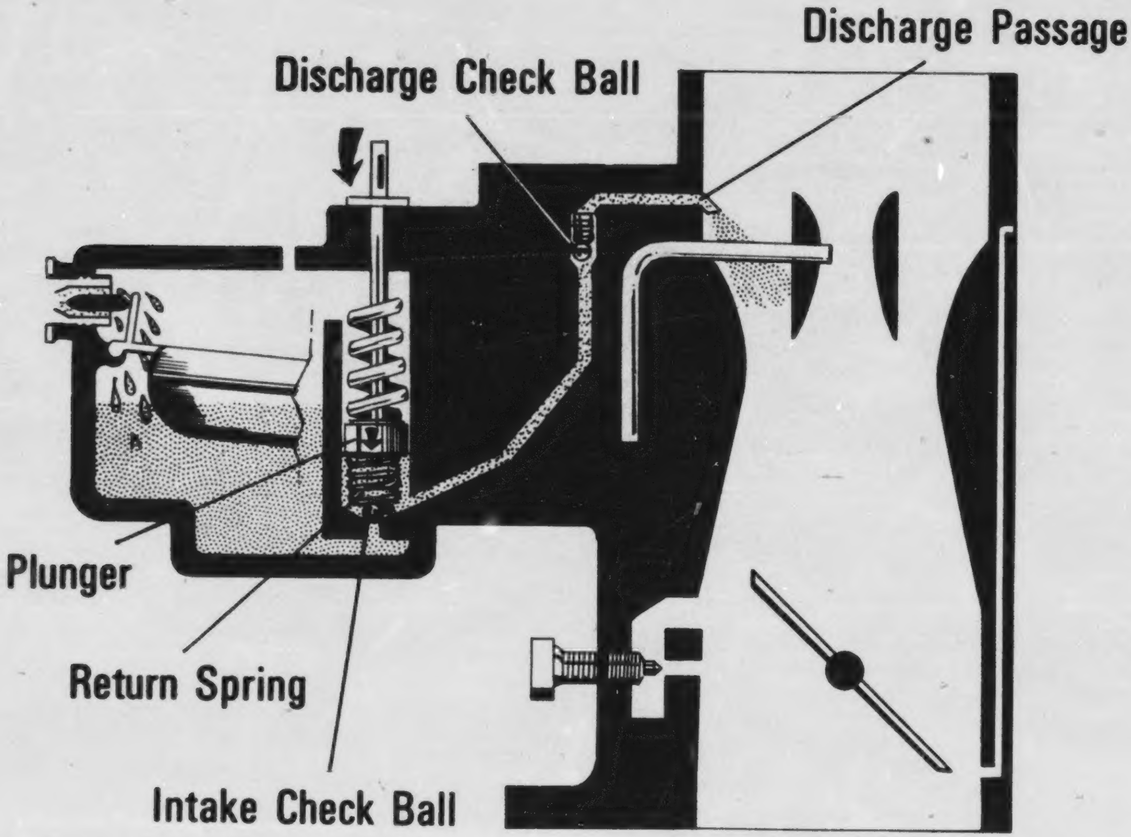
Main Metering System


Main Well
Air Bleed
Air Bleeds
Main Nozzle
Metering Jet
Main Well

Power System

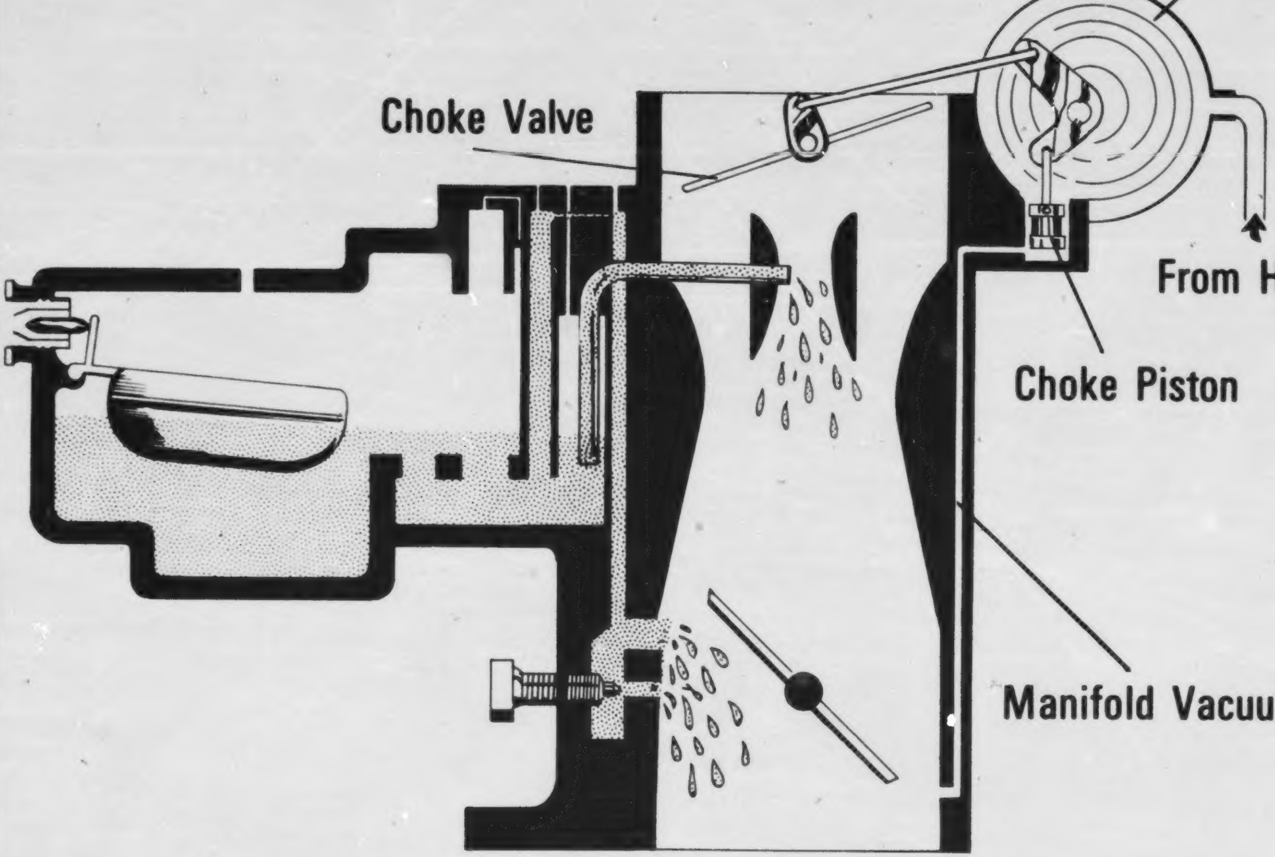

Manifold Vacuum
Power Piston
Power Valve

Accelerator Pump System


Discharge Passage
Discharge Check Ball
Plunger
Return Spring
Intake Check Ball

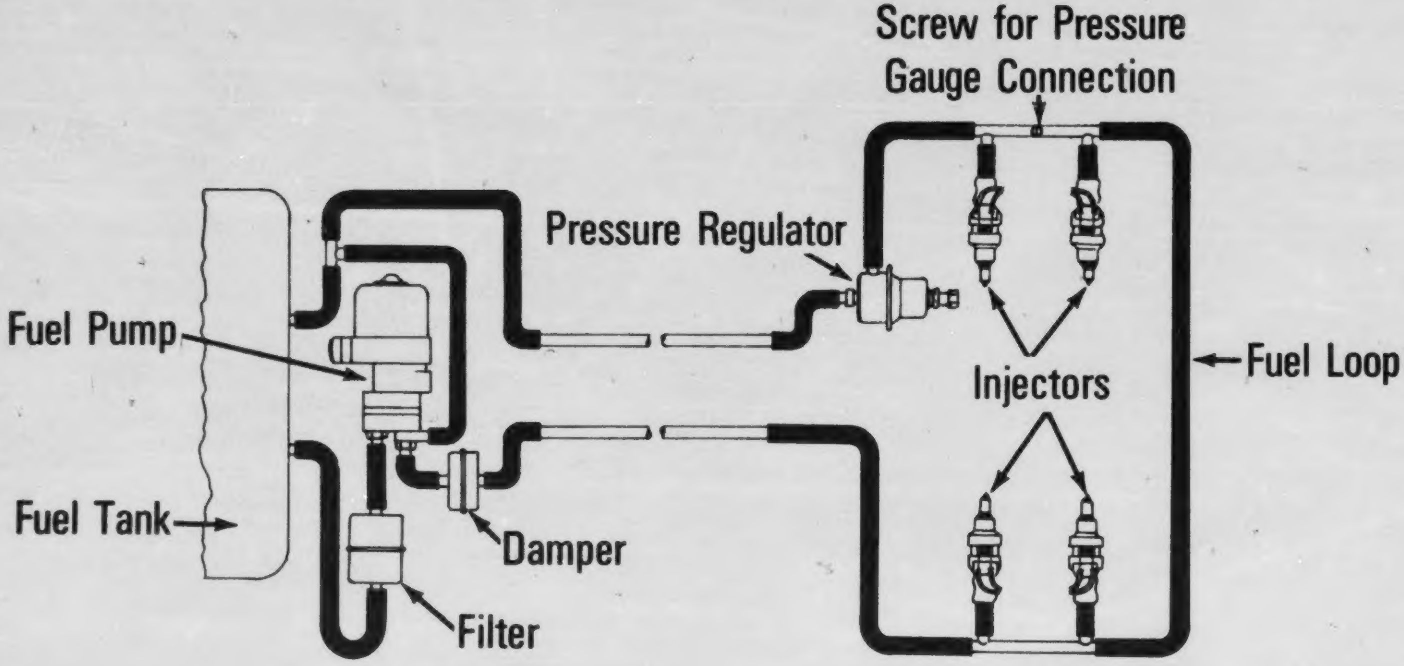
AM I - 227-C

Choke System

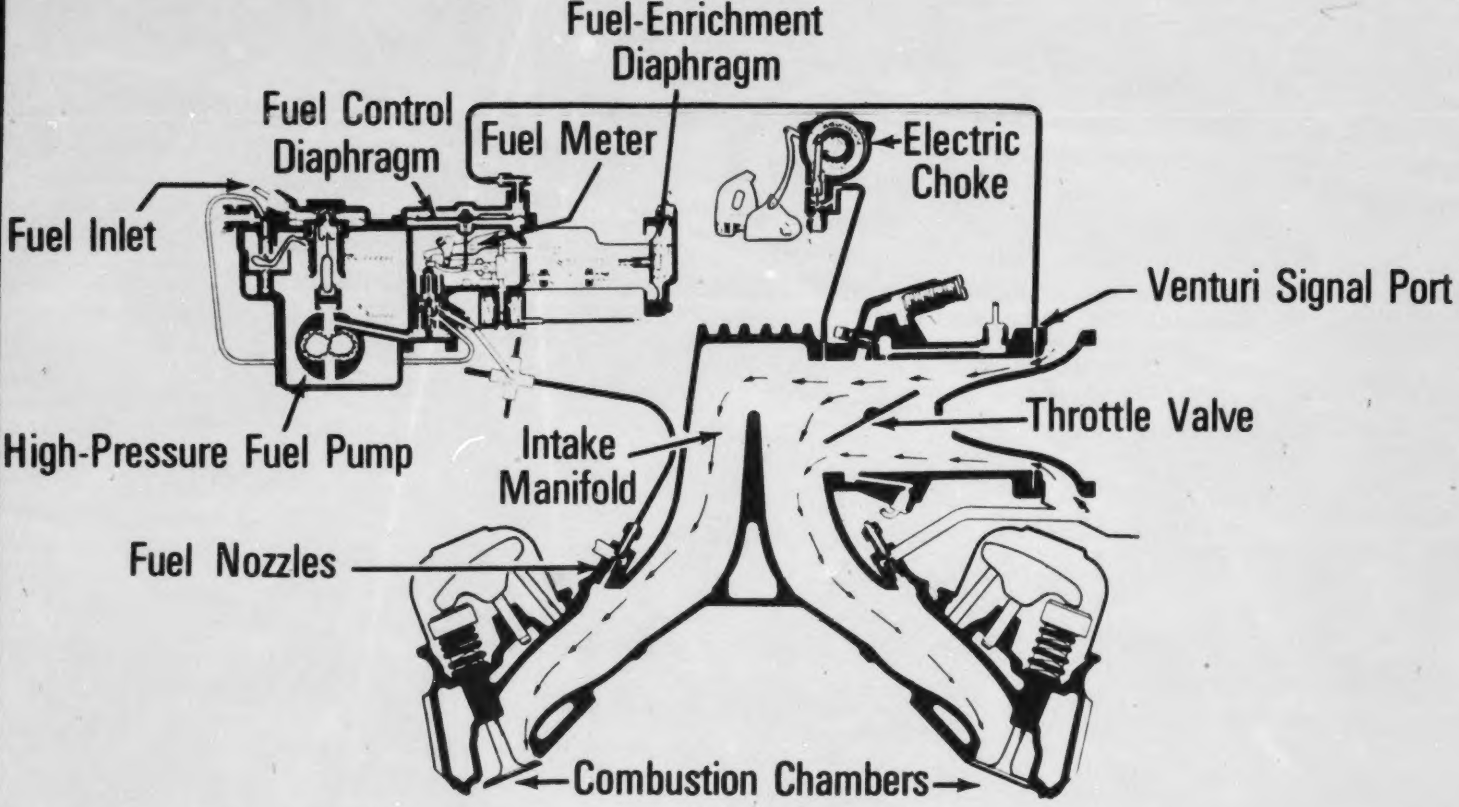

Thermostatic Coil
Choke Valve
From Heat Stove
Choke Piston
Manifold Vacuum

AM I - 229-C

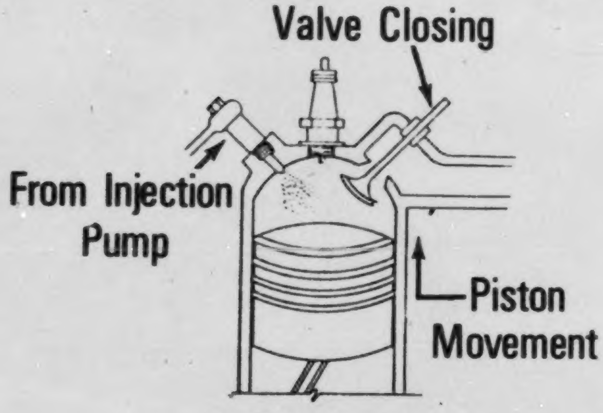
Electronic Fuel Injection


Screw for Pressure Gauge Connection
Pressure Regulator
Fuel Pump
Injectors
Fuel Loop
Fuel Tank
Damper
Filter

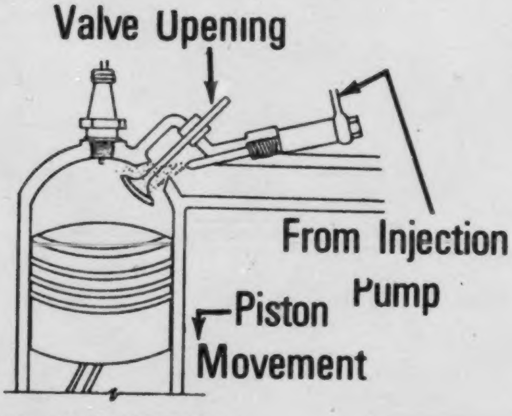
Mechanical Fuel Injection


Fuel-Enrichment Diaphragm
Fuel Control Diaphragm
Fuel Meter
Electric Choke
Fuel Inlet
Venturi Signal Port
Throttle Valve
High-Pressure Fuel Pump
Intake Manifold
Fuel Nozzles
Combustion Chambers

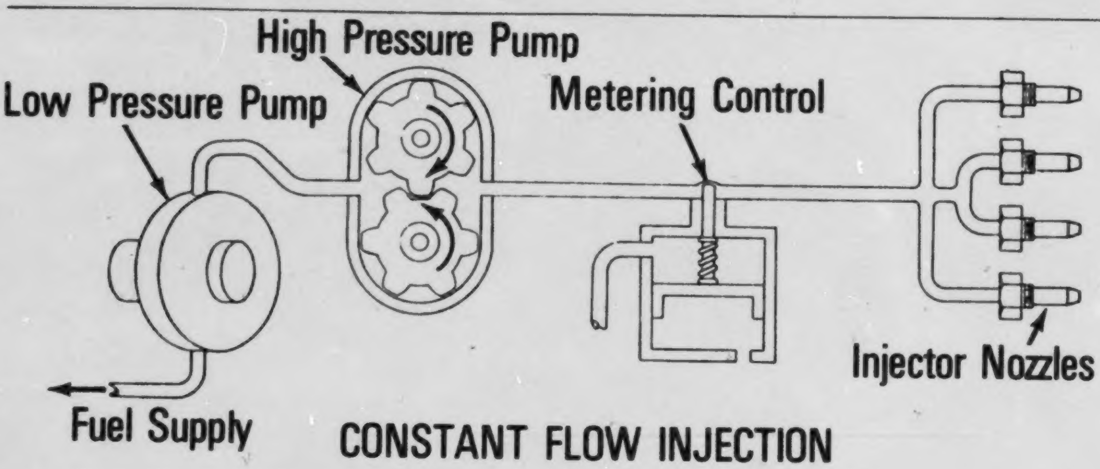
Variations of Fuel Injection Systems


Valve Closing
From Injection Pump
Piston Movement

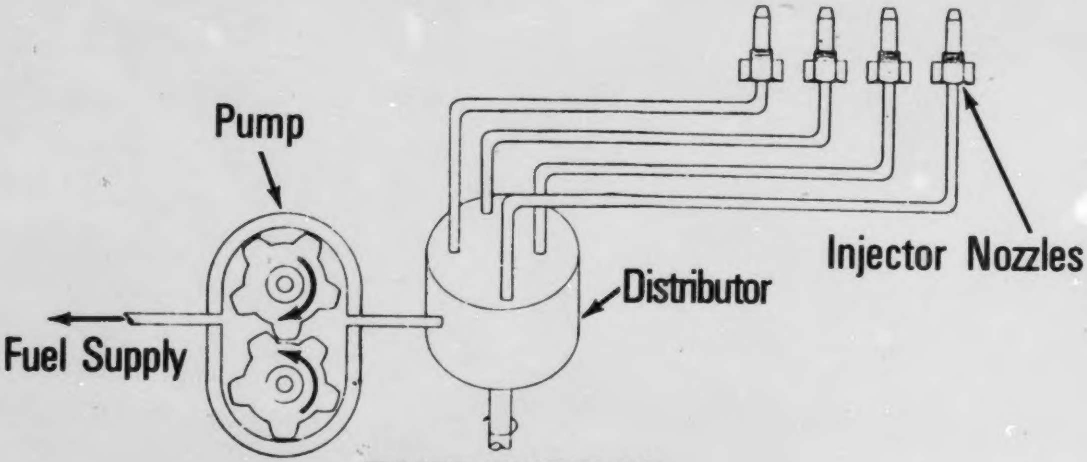
COMBUSTION CHAMBER INJECTION


Valve Opening
From Injection Pump
Piston Movement

PORT INJECTION


High Pressure Pump
Low Pressure Pump
Metering Control
Injector Nozzles
Fuel Supply

CONSTANT FLOW INJECTION


Pump
Fuel Supply
Distributor
Injector Nozzles

TIMED INJECTION

FUEL SYSTEM
UNIT V

JOB SHEET #1--VOLUME AND PRESSURE TEST A FUEL PUMP

I. Tools and equipment

- A. Suitable fuel pump pressure and volume tester
- B. Combination end wrenches, 7/16" - 5/8" (11 mm - 16 mm)
- C. Fuel line hose clamp pliers
- D. Sockets, 7/16" - 9/16" (11 mm - 15 mm), 3/8" drive
- E. Ratchet, 3/8" drive
- F. Extensions, 3" and 6" (7.5 cm and 15 cm), 3/8" drive

II. Procedure

A. Tighten the pump diaphragm and mounting screws before testing the fuel pump

(NOTE: Inspect lines for kinks, dents, and leaks. Make sure there is ample gas in the tank.)

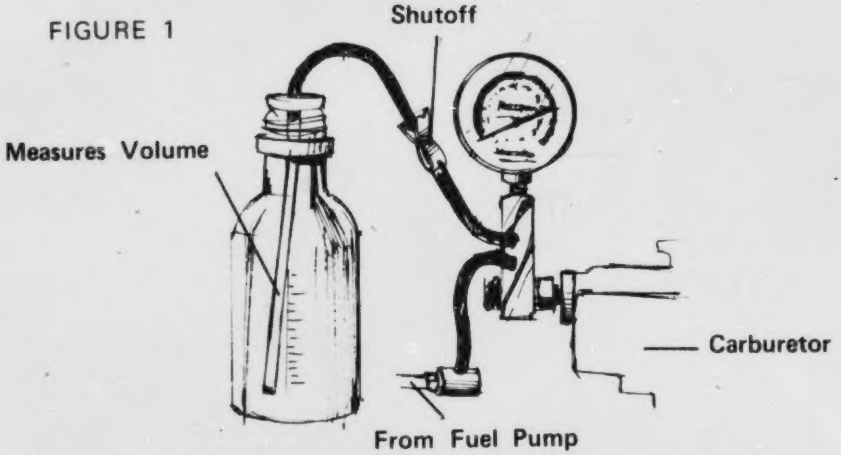
B. Remove the air cleaner

C. Disconnect main fuel line at the carburetor

D. Connect fuel pump tester to carburetor

(NOTE: Use adapters as required. See Figure 1.)

FIGURE 1



JOB SHEET #1

E. Connect fuel line to fitting on fuel pump tester hose

(NOTE: Use adapters as required.)

F. Close shut-off valve on fuel discharge hose of tester

(CAUTION: Use extreme care when conducting both pressure and volume tests. A fuel pump can spray fuel a long distance. Make certain all connections are tight and that the volume hose is in the container.)

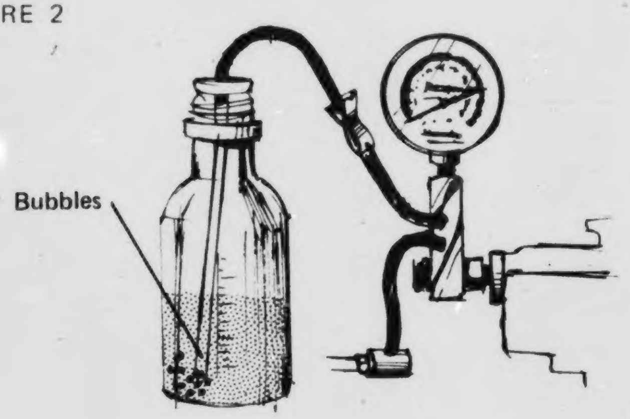
G. Start engine and adjust speed to approximately 500 rpm

H. Make sure volume hose is in the graduated container

I. Open shut-off valve and observe the amount of time required to pump one pint of fuel

(NOTE: When fuel reaches the four-ounce level, the end of the hose should be submerged and watched for bubbles. See Figure 2.)

FIGURE 2



J. Close the shut-off valve on the hose securely when the one pint level is reached

K. Note the gauge reading on the fuel pump tester with the engine still running at test speed

L. Shut off engine

M. Compare volume and pressure test readings with vehicle manufacturer's specifications

(NOTE: Be sure to dispose of fuel in graduated container to avoid fire hazard.)

JOB SHEET #1

N. Remove fuel pump tester from engine

O. Connect fuel line to carburetor

(NOTE: Use a backup wrench to avoid twisting the fuel line.)

P. Tighten all lines securely

Q. Install the air cleaner

R. Start engine

S. Check for leaks

(CAUTION: Secure all fuel lines and double-check tightness of connections to prevent fuel leaks.)

FUEL SYSTEM
UNIT V

JOB SHEET #2--REMOVE AND REPLACE A FUEL PUMP

I. Tools and equipment

A. Combination end wrenches, 7/16" - 5/8" (11 mm - 16 mm)

B. Fuel hose clamp pliers

C. Sockets, 7/16" - 9/16" (11 mm - 15 mm), 3/8" drive

D. Ratchet, 3/8" drive

E. Extensions, 3" and 6" (7.5 cm and 15 cm), 3/8" drive

F. Fender cover

G. Shop towels

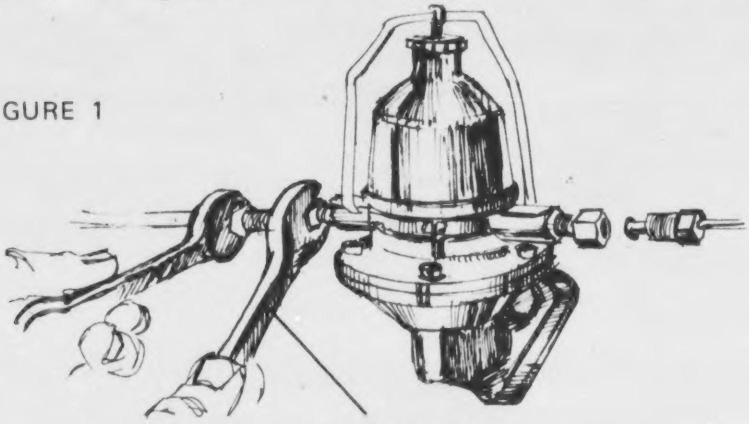
H. Gasket sealer

II. Procedure

A. Disconnect fuel lines from fuel pump

(NOTE: Use a backup wrench on all fuel lines and fittings to avoid twisting the line. See Figure 1.)

FIGURE 1



(CAUTION: Make sure fuel is not flowing from the inlet fuel line. If fuel is flowing, it must be plugged to prevent the danger of fire.)

JOB SHEET #2

B. Remove other vacuum or return lines if required

C. Remove the fasteners that attach the fuel pump to the engine

D. Remove fuel pump

(NOTE: Observe the shape and location of the fuel pump arm. Check the location of the fuel pump push rod if used.)

E. Clean fuel pump mounting surface on the engine

F. Coat the mounting surfaces of the fuel pump and engine with gasket sealer

G. Install a new mounting gasket on the fuel pump

(NOTE: Study the shape of the rocker arm and note the positioning of the pad.)

H. Check location of cam or push rod and install pump to make correct contact (Figure 2)

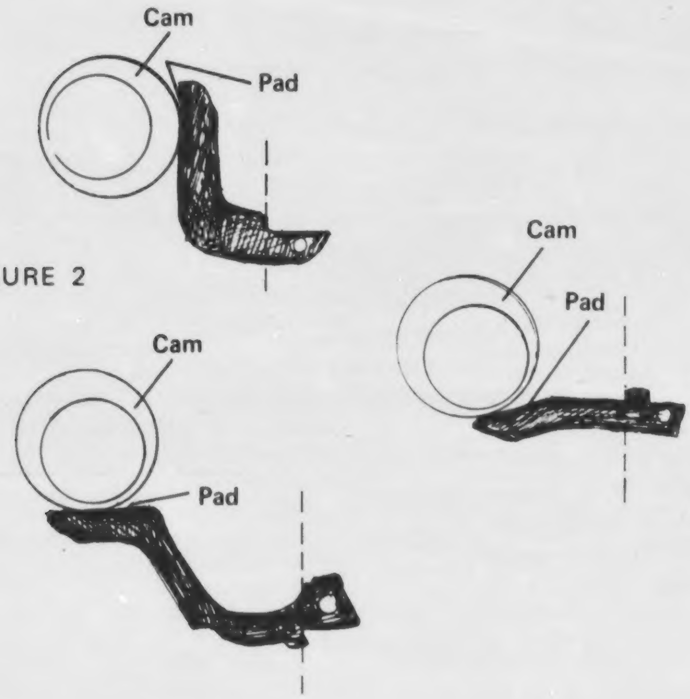
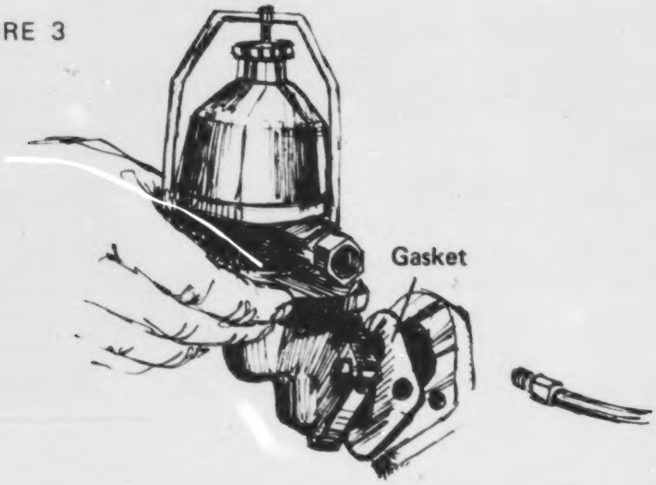


FIGURE 2

JOB SHEET #2

I. Shove pump inward until the mounting flange is against the mounting pad (Figure 3)

FIGURE 3



J. Install fasteners and torque to specifications

(NOTE: Make sure the pump is free to move against the mounting pad before tightening the bolts.)

K. Attach the fuel lines, hose, or other lines as required

(NOTE: Fittings must align to prevent cross-threading.)

L. Tighten fuel lines securely

(NOTE: Hold pump fitting with one wrench while tightening flare nut with the other to prevent fuel line damage.)

M. Start engine

N. Check for leaks

(CAUTION: Secure all fuel lines and double-check tightness of connections to prevent fuel leaks.)

FUEL SYSTEM
UNIT V

JOB SHEET #3--SERVICE AN AIR CLEANER

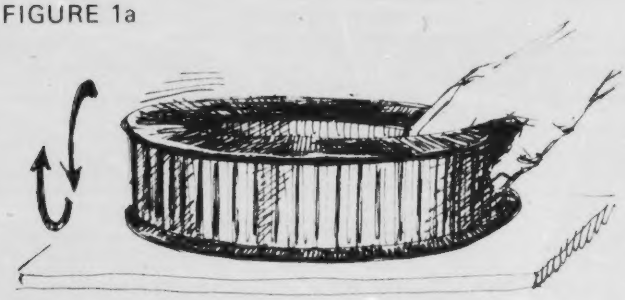
I. Tools and equipment

- A. Compressed air
- B. Container of solvent
- C. Cleaning brush
- D. Shop towels
- E. Screwdriver

II. Procedure

- A. Remove the air cleaner fasteners
- B. Remove the air cleaner and air cleaner cover
- C. Determine the type of air cleaner element
  - 1. Paper air cleaner element
    - a. Should be replaced at specified intervals
    - b. May be cleaned between intervals of replacement by tapping lightly on a flat surface or by directing a controlled stream of compressed air through the element opposite normal air flow (Figures 1a and 1b)

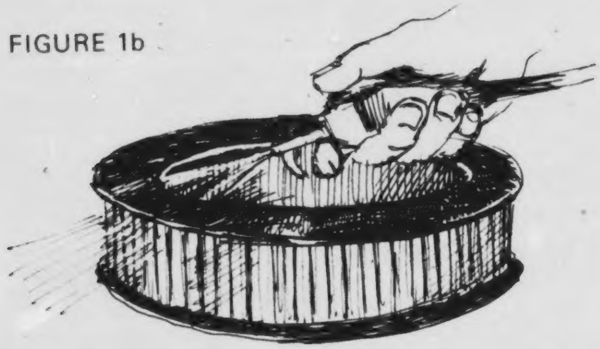
FIGURE 1a



Tap lightly on a flat surface

JOB SHEET #3

FIGURE 1b



Direct a controlled stream of air through filter

c. Check the element against the light before reinstalling to make sure there are no holes or ruptures present

d. Check bottom and top gasket surfaces of the paper element for damage

e. Install right side up where indicated

2. Polyurethane element

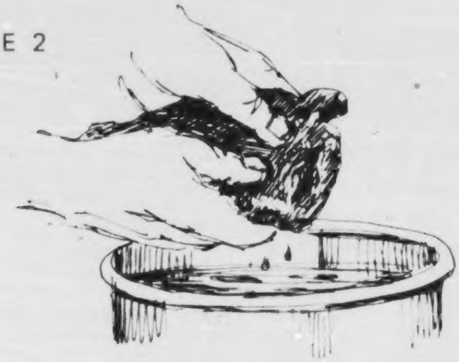
   a. Remove the polyurethane element from the support screen

   b. Wash it thoroughly in clean solvent

   c. Squeeze out the solvent (Figure 2)

   (NOTE: Do not wring because the element might tear.)

FIGURE 2



JOB SHEET #3

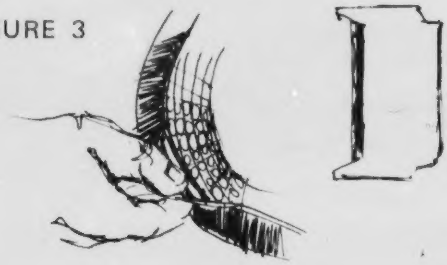
d. Re-oil the filter element with clean engine oil

e. Squeeze excess oil from filter element

f. Replace element on support screen (Figure 3)

(NOTE: Make sure the element is placed on the support screen to form a sound seal for both top and bottom contact edges.)

FIGURE 3

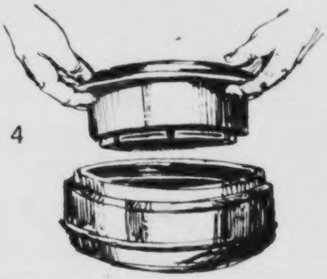


3, Oil bath air cleaner

a. Remove wing nut

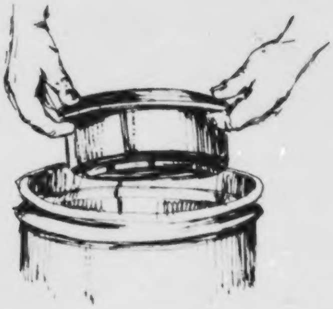
b. Lift out gauze air strainer (Figure 4)

FIGURE 4



c. Rinse air strainer in clean solvent (Figure 5)

FIGURE 5



JOB SHEET #3

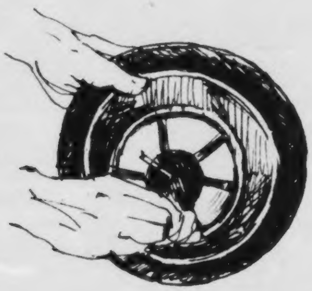
d. Shake excessive solvent from the air strainer

e. Saturate the air strainer gauze with light oil and allow excess to drip off

f. Pour out oil in lower body and discard

g. Wash dirt and grit out of lower body with clean solvent (Figure 6)

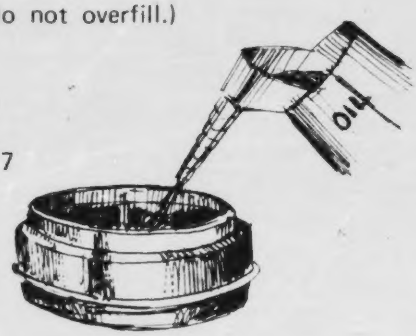
FIGURE 6



h. Fill lower body to correct level with fresh engine oil of sufficient SAE specification (Figure 7)

(NOTE: Do not overfill.)

FIGURE 7



i. Place units together and install wing nut

(NOTE: Make sure gasket is in place between the air strainer and lower body.)

j. Tighten wing nut securely

D. Clean the filter body and cover before replacing

JOB SHEET #3

E. Make certain that the gasket between the air cleaner and carburetor is in good condition and is in place; replace if necessary

F. Replace the air cleaner body

(NOTE: Make sure the air cleaner faces in the correct direction. If a locating tang or lug is present, make sure it engages properly.)

G. Tighten the air cleaner wing nut

(NOTE: Avoid overtightening because it could cause improper operation of the choke.)

H. Install other hoses or vacuum lines as required

FUEL SYSTEM
UNIT V

JOB SHEET #4--REMOVE AND REPLACE A CARBURETOR

I. Tools and equipment

A. Combination end wrenches, 7/16" - 5/8" (11 mm - 16 mm)

B. Sockets, 7/16" - 5/8" (11 mm - 15 mm), 3/8" drive

C. Ratchet, 3/8" drive

D. Extension, 6" (15 cm), 3/8" drive

E. Adjustable end wrench, 10"

F. Screwdriver

G. Fender covers

H. Fuel hose clamp pliers

II. Procedure

A. Remove the air cleaner

B. Disconnect the fuel line

(NOTE: Use a backup wrench to avoid twisting the fuel line.)

C. Disconnect vacuum lines if necessary

D. Disconnect the throttle linkage

E. Disconnect the choke control cable on manual choke if required

F. Disconnect the heat tube or automatic choke linkage as required

G. Remove any accessories that will interfere with the removal of the carburetor

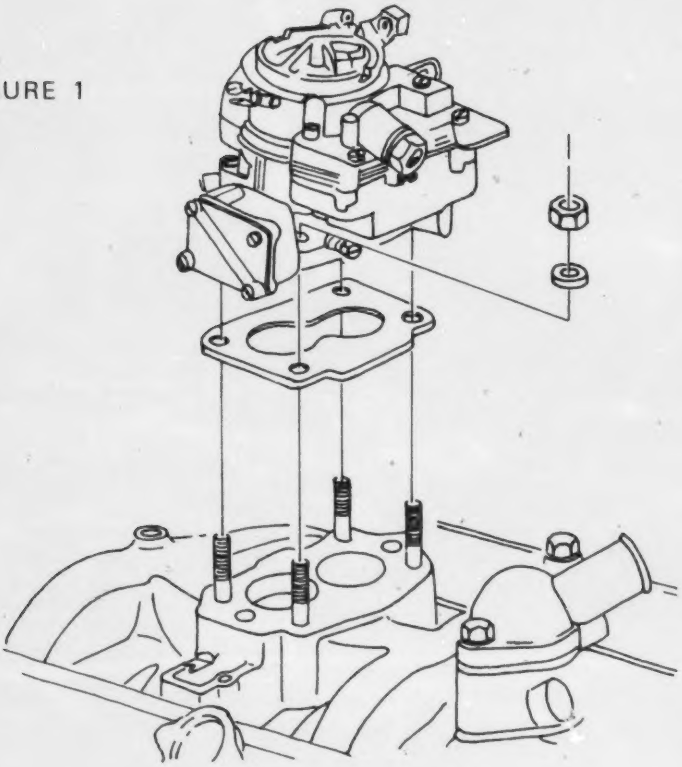
H. Remove the fasteners that hold the carburetor on the manifold

JOB SHEET #4

I. Remove the carburetor (Figure 1)

(NOTE: Use extreme care to avoid dropping bolts, nuts, or any foreign material in the manifold opening when the carburetor is removed.)

FIGURE 1



(Courtesy Chevrolet Motor Division, General Motors Corporation)

J. Remove the old carburetor base gasket

K. Clean the gasket mounting surface

(NOTE: Cover the manifold opening with a shop towel during cleaning or underhood work.)

JOB SHEET #4

L. Install the new carburetor base gasket

M. Place the carburetor in the correct position and start fasteners

N. Tighten and torque carburetor fasteners

O. Replace vacuum lines as required

P. Replace throttle linkage

Q. Connect the automatic choke linkage or heat tube as required

R. Connect the fuel line to carburetor

(NOTE: Use caution to avoid cross-threading.)

S. Tighten the fuel line securely

(NOTE: Use a backup wrench to avoid fuel line twisting.)

T. Check to make sure all connections and accessories are secure

U. Start the engine

V. Check for leaks

(CAUTION: Secure all fuel lines and double-check tightness of connections to prevent fuel leaks.)

W. Make idle air mixture and idle speed adjustments as required

X. Replace air cleaner

(NOTE: Make sure it is securely in place and positioned correctly.)

FUEL SYSTEM
UNIT V

JOB SHEET #5--DISASSEMBLE, ADJUST, AND REASSEMBLE A CARBURETOR

I. Tools and equipment

   A. Screwdrivers, assorted sizes

   B. Pliers

   C. Phillips screwdriver

   D. Adjustable end wrench, 10"

   E. Needle nose pliers

   F. Suitable carburetor adjusting tools

   G. Rochester 2GC carburetor

II. Procedure

   A. Air horn disassembly

      (NOTE: Refer to Figure 1 on the following page.)

      1. Remove fuel inlet fitting, gasket, and filter

      2. Remove the idle vent valve retaining screw shield and vent

      3. Remove retainer clips from the choke and unloader rod

      4. Remove the choke and unloader rods

      5. Remove the spring clips from the upper end of the pump rod at the pump lever

      6. Disconnect the upper end of the pump rod

      7. Remove the air horn attaching screws

      8. Remove the air horn

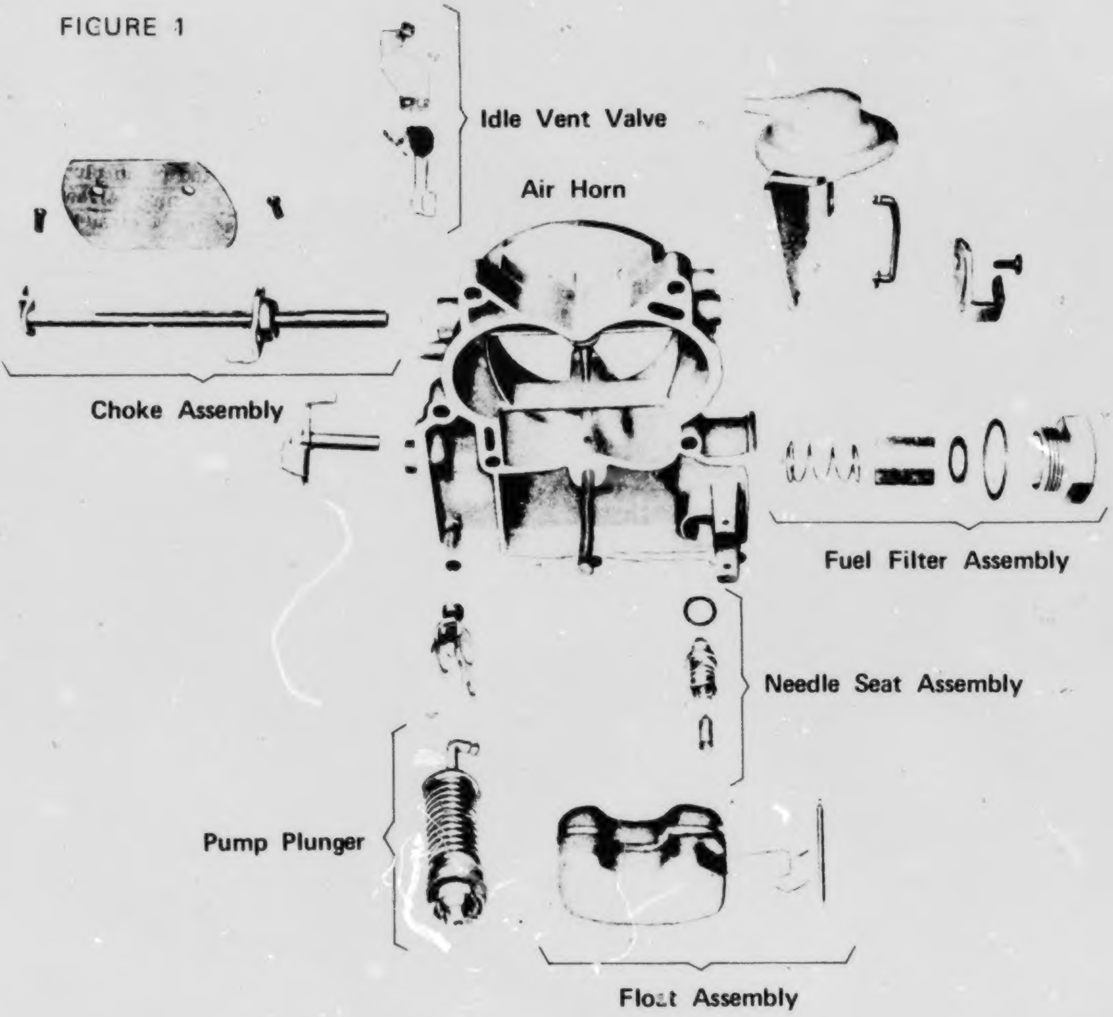
      9. Invert the air horn

      10. Remove the float hinge pin and float

      11. Remove needle assembly

JOB SHEET #5

FIGURE 1


Idle Vent Valve
Air Horn
Choke Assembly
Fuel Filter Assembly
Needle Seat Assembly
Pump Plunger
Float Assembly

(Courtesy Chevrolet Motor Division, General Motors Corporation)

JOB SHEET #5

12. Remove the needle seat and gasket

13. Remove the retainer from the pump plunger shaft; remove pump plunger

14. Remove the air horn gasket

15. Remove the choke valve or shaft if required

B. Float bowl disassembly

(NOTE: Refer to Figure 2 on the following page.)

1. Remove pump plunger return spring and check ball as required

2. Remove main metering jets and power valve

3. Remove venturi cluster attaching screws and the venturi cluster

4. Remove the pump discharge spring guide, spring, and ball

5. Invert fuel bowl

6. Remove throttle body attaching screws

7. Remove throttle body and gasket

C. Throttle body and choke disassembly

(NOTE: Refer to Figure 2 on the following page.)

1. Remove the fast idle cam attaching screw

2. Remove the choke cover screws and cover

3. Remove the cover gasket and baffle plate from choke housing

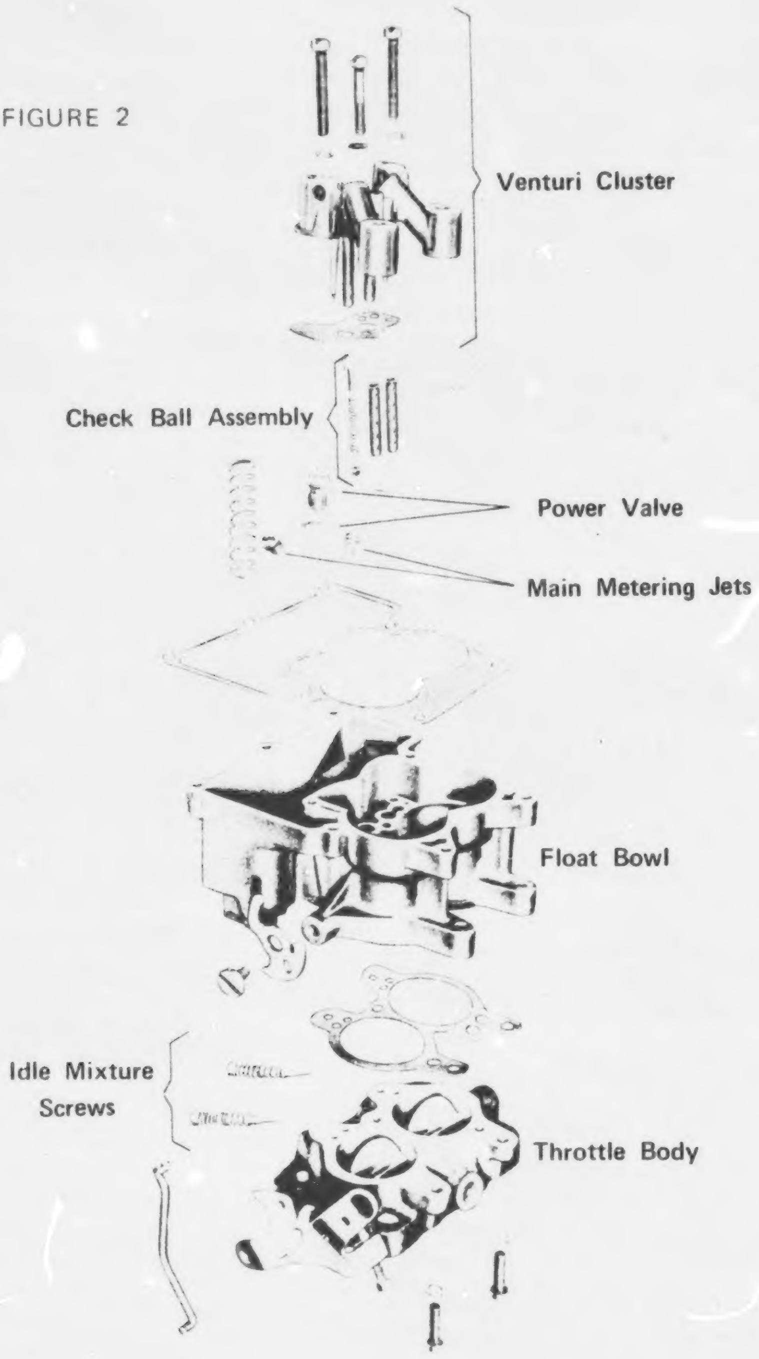
4. Remove the choke piston attaching screw and the piston link and lever assembly

5. Remove the choke housing attaching screws and the choke housing

6. Remove the choke housing gasket, choke lever, and linkage from the choke housing

JOB SHEET #5

FIGURE 2


Venturi Cluster
Check Ball Assembly
Power Valve
Main Metering Jets
Float Bowl
Idle Mixture Screws
Throttle Body

(Courtesy Chevrolet Motor Division, General Motors Corporation)

JOB SHEET #5

7. Remove idle mixture needle screws as required for cleaning or replacement

   (NOTE: No attempt should be made to remove the throttle valves or shafts.)

D. Cleaning of parts

1. Clean the carburetor castings and metal parts thoroughly in carburetor solvent

   (NOTE: The choke coil, housing, and pump plunger should not be immersed in solvent.)

2. Clean and dry all passages in casting with compressed air

   (NOTE: Do not pass drills through jets or passages.)

E. Inspection of parts

1. Check float for dents or excessive wear at hinge pin holes
2. Shake float to check for leaks
3. Examine float needle and seat for ridges; replace with a new matched set as required
4. Inspect the idle mixture adjusting needles for burrs or ridges; replace if necessary
5. Inspect all linkage and linkage arms for excessive wear; replace as required
6. Inspect the pump plunger for cracks or creases; replace if damaged
7. Inspect the throttle body to make sure idle passages and vacuum channels are open

F. Throttle body assembly

1. Install the slow idle speed screw if removed
2. Install the fast idle lever on the end of the throttle shaft with attaching screw if removed; install the fast idle speed screw and spring in the lever

JOB SHEET #5

3. Install the idle mixture needles and spring in the throttle body if removed

   (NOTE: Tighten finger tight, then back out 1 1/2 turns as a preliminary idle adjustment.)

4. Install the choke lever and shaft in the choke shaft

5. Install the choke housing gasket and choke housing

6. Install the choke piston lever and link assembly

7. Position the fast idle cam on the throttle body and install attaching screw

8. Place a new gasket on the bottom of the float bowl, align holes, and install the throttle body screws; tighten evenly and securely

G. Float bowl assembly

1. Install the pump discharge ball, spring, and guide

2. Install the venturi cluster, gasket, and attaching screws

   (NOTE: Screw with gasket must be inserted in center hole.)

3. Install the main metering jets and power valve

4. Install the pump inlet ball and return spring in the pump well

5. Install screen and baffle if required

H. Air horn assembly

1. Install choke unloader if removed

2. Install choke shaft and choke valve if removed

   (NOTE: Center the choke valve in the choke shaft before tightening screws.)

3. Install the pump plunger

4. Position the float needle seat gasket and install seat in the air horn

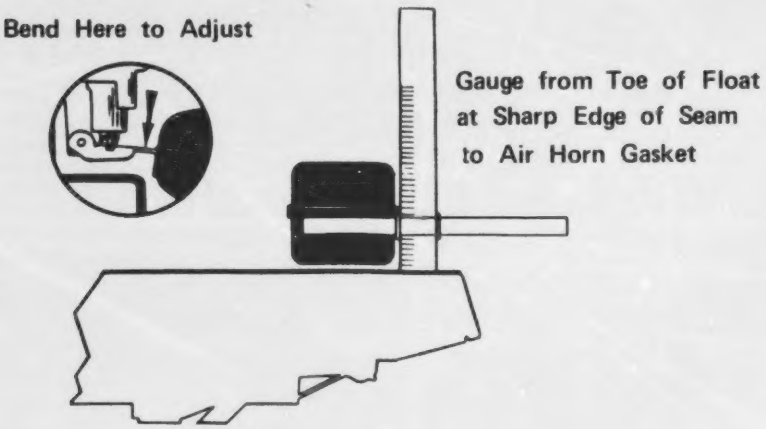
5. Install the power piston and lightly stake the casting; make sure piston moves freely

JOB SHEET #5

6. Install the air horn gasket, float, and needle assembly and float hinge pin

7. Adjust float level, using manufacturer's specifications (Figure 3)

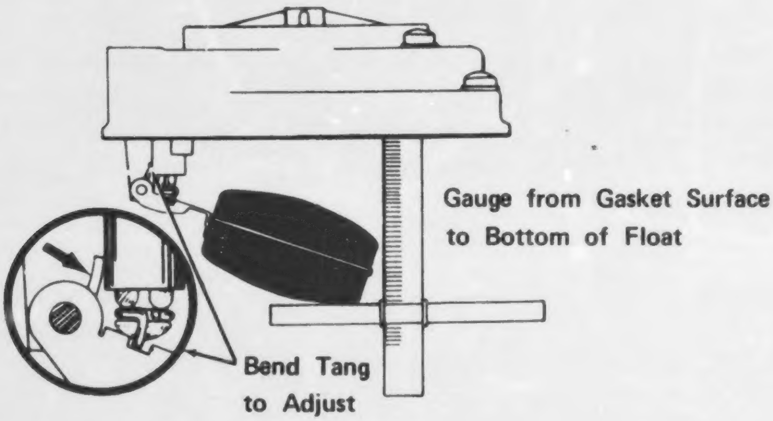
FIGURE 3


Bend Here to Adjust
Gauge from Toe of Float at Sharp Edge of Seam to Air Horn Gasket

(Courtesy Chevrolet Motor Division, General Motors Corporation)

8. Adjust float drop, using manufacturer's specifications (Figure 4)

FIGURE 4


Gauge from Gasket Surface to Bottom of Float
Bend Tang to Adjust

(Courtesy Chevrolet Motor Division, General Motors Corporation)

JOB SHEET #5

I. Completion of carburetor assembly

1. Install the air horn on the float bowl while guiding accelerator pump in place; install and tighten air horn screws evenly and securely
2. Position the upper end of the pump rod on the pump lever and retain with spring clip
3. Position idle vent valve and shield on air horn and retain with attaching screw
4. Install choke unloader screw
5. Make additional adjustments according to manufacturer's recommendations

FUEL SYSTEM
UNIT V

TEST

1. Write the purpose of the fuel system.

2. Define the following terms.

   a. Atomization--

   b. Venturi--

   c. Metering--

3. List one purpose for each of the following components of the fuel system.

   a. Fuel tank--

   b. Fuel filter--

   c. Fuel pump--

   d. Carburetor--

   e. Fuel line--

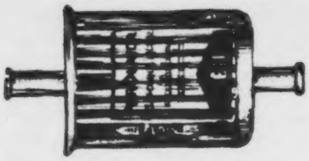
   f. Air cleaner--

4. Describe the fuel pump operation during the inlet and outlet strokes.

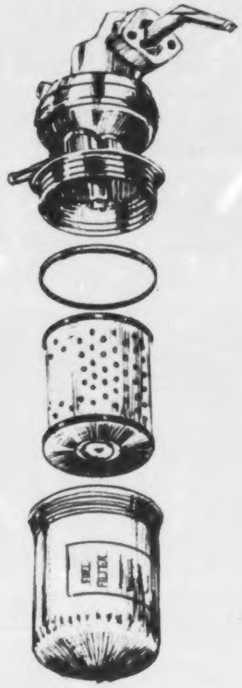
   a. Inlet stroke

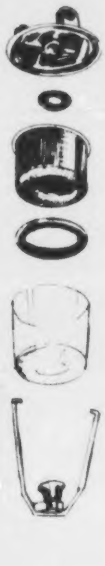
   b. Outlet stroke

5. Identify the following types of fuel filters.



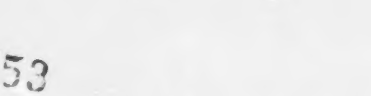
a. ______________________________


FUEL FILTER



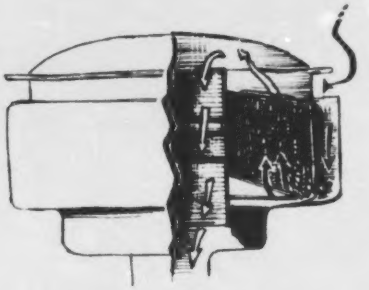
c. ______________________________

b. ______________________________

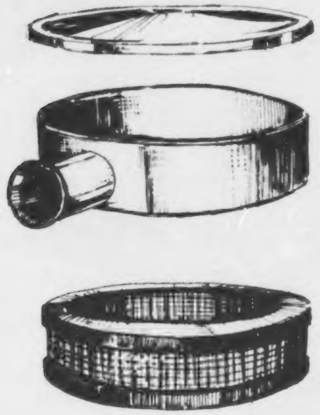


d. ______________________________

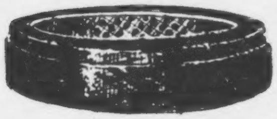
6. Identify the following types of air cleaners.



a.____________________________________

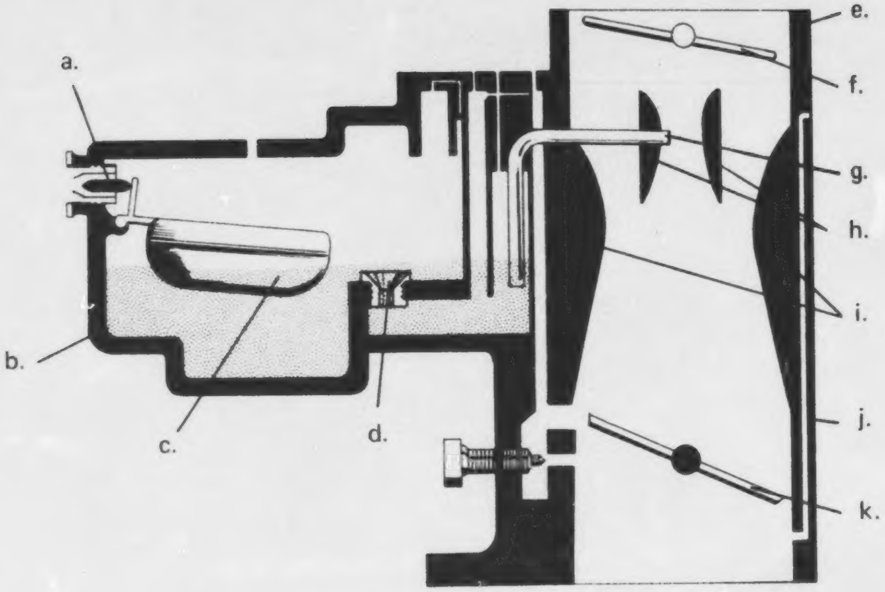


b.____________________________________



c.____________________________________

7. Identify the parts of the carburetor illustrated below.


a.
b.
c.
d.
e.
f.
g.
h.
i.
j.
k.

a. ______________________

b. ______________________

c. ______________________

d. ______________________

e. ______________________

f. ______________________

g. ______________________

h. ______________________

i. ______________________

j. ______________________

k. ______________________

8. Match the carburetor systems on the right with the correct use.

_____a. Provides fuel delivery during operation with the throttle partly to fully opened

_____b. Provides a richer mixture for cold engine starting and operation

_____c. Temporarily provides extra fuel necessary to overcome the leanness caused by rapid throttle opening

_____d. Maintains a given depth of fuel in the float bowl

_____e. Provides fuel delivery during closed or nearly closed throttle

_____f. Provides extra fuel for maximum engine power to supplement the main metering system

1. Float system
2. Idle system
3. Main metering system
4. Power system
5. Accelerator pump system
6. Choke system

9. Match the types of gasoline additives on the right to the correct purposes.

_____a. Prevents rust and corrosion in storage tanks, lines, and fuel systems

_____b. Prevents pre-ignition

_____c. Indicates presence of antiknocks; identifies various makes or grades of gasoline

_____d. Prevents formation of ice in storage tanks, lines, and fuel systems

_____e. Prevents gum formation during the normal life of the fuel

_____f. Combats surface ignition and spark plug fouling

_____g. Prevents lead deposits from accumulating on inside of carburetor

1. Dye
2. Carburetor detergent
3. Anti-icing agent
4. Antirust additive
5. Antioxident additive
6. Deposit modifier additive
7. Antiknock compound

10. Discuss fuel injection.

11. List the variations of fuel injection systems.

    a.

    b.

    c.

    d.

    e.

    f.

12. Demonstrate the ability to:

    a. Volume and pressure test a fuel pump.

    b. Remove and replace a fuel pump.

    c. Service an air cleaner.

    d. Remove and replace a carburetor.

    e. Disassemble, adjust, and reassemble a carburetor.

    (NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

FUEL SYSTEM
UNIT V

ANSWERS TO TEST

1. To supply a combustible mixture of air and fuel to the engine cylinders to meet all driving conditions

2.
   a. Atomization--The breaking of a liquid into tiny particles or globules to aid evaporation
   b. Venturi--Restriction in the carburetor which makes the air speed up, causing a high vacuum
   c. Metering--Correct proportions of fuel and air for good combustion

3.
   a. Fuel tank--Stores fuel for engine use
   b. Fuel filter--Prevents dirt and foreign matter from entering the carburetor
   c. Fuel pump--Pumps fuel from the fuel tank to the carburetor
   d. Carburetor--Mixes fuel and air in the proper proportion for a combustible mixture
   e. Fuel line--Carries fuel from the fuel tank to the carburetor
   f. Air cleaner--Filters grit and dust from the air entering the carburetor

4.
   a. Inlet stroke
      1. Diaphragm flexed downward, forming a vacuum
      2. Inlet check valve opens
      3. Fuel is drawn into pump
   b. Outlet stroke
      1. Diaphragm is pushed upward by return spring
      2. Inlet valve is forced shut
      3. Outlet valve is forced open
      4. Fuel is forced out of pump

5. a. In-line
   b. Bowl
   c. Disposable element
   d. Carburetor inlet

6. a. Oil bath
   b. Paper element
   c. Polyurethane

7. a. Needle valve assembly
   b. Float bowl
   c. Float
   d. Jet
   e. Air horn
   f. Choke valve
   g. Nozzle
   h. Venturi cluster
   i. Venturi
   j. Throttle body
   k. Throttle valve

8. a. 3 d. 1
   b. 6 e. 2
   c. 5 f. 4

9. a. 4 e. 5
   b. 7 f. 6
   c. 1 g. 2
   d. 3

10. Discussion should include--Fuel is injected under pressure directly into cylinder or into intake air flow instead of mixing with air at carburetor prior to distribution

11. a. Mechanical
    b. Electronic
    c. Combustion chamber injection
    d. Port injection
    e. Constant flow injection
    f. Timed injection

12. Performance skills evaluated to the satisfaction of the instructor

[redacted]

WHEEL BEARINGS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify types of front wheel bearings and parts of a tapered roller front wheel bearing assembly and perform necessary maintanence on the assembly. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with wheel bearings to the correct definitions.
2. Identify the types of front wheel bearings.
3. Identify the parts of a tapered roller front wheel bearing assembly.
4. List characteristics of quality wheel bearing grease.
5. State precautions to observe while packing wheel bearings.
6. Demonstrate the ability to:
    a. Clean and inspect a bearing.
    b. Adjust front wheel bearings.
    c. Pack a front wheel bearing assembly.

WHEEL BEARINGS
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information sheet.
- F. Demonstrate and discuss procedures outlined in the job sheets.
- G. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Demonstrate the ability to accomplish the procedures outlined in the job sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
  1. TM 1--Parts of a Tapered Roller Front Wheel Bearing
  2. TM 2--Types of Front Wheel Bearings
  3. TM 3--Parts of a Tapered Roller Front Wheel Bearing Assembly

D. Job sheets

    1. Job Sheet #1--Clean and Inspect a Bearing

    2. Job Sheet #2--Adjust Front Wheel Bearings

    3. Job Sheet #3--Pack a Front Wheel Bearing Assembly

E. Test

F. Answers to test

II. References:

A. *Chevrolet Service Manual.* Detroit, Michigan: Chevrolet Motor Div./General Motors Corp., 1973.

B. *Plymouth Service Manual.* Detroit, Michigan: Chrysler-Plymouth Div./Chrysler Corp., 1975.

C. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1971.

D. Bacon, E. Miles. *Principles of Wheel Alinement Service.* New York: McGraw-Hill Book Co., 1971.

E. Stockel, Martin W. *Auto Service and Repair.* Homewood, Illinois: Goodheart-Willcox Co., 1969.

F. Toboldt, William K., and Johnson, Larry. *Motor Services Automotive Encyclopedia.* South Holland, Illinois: Goodheart-Willcox Co., 1970.

G. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: McGraw-Hill Book Co., 1975.

WHEEL BEARINGS
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Antifriction bearing--Bearing containing rollers or balls plus an inner and outer race that allows the load to roll on the balls or rollers thus minimizing friction

B. Bearing race--Surface of the groove or path on which the balls or rollers of a bearing roll (Transparency 1)

C. Press fit--Installation of a bearing cup with a tight or interference fit requiring more than hand force to install

D. Push fit--Installation of a bearing cone with a light fit that can be installed with hand pressure

E. Bearing cone--Part of the roller bearing which contains the inner race, roller cage, and rollers; installed on the spindle with a push fit (Transparency 1)

F. Bearing cup--Part of the bearing which contains the outer race; installed in the hub with a press fit (Transparency 1)

G. Bearing creep--Very slow, steady rotation of a push fit bearing race to keep changing the area of greatest load and thus increase bearing life

H. Preload--Adjustment of antifriction bearings so that they will work under mild pressure

I. End play--Amount of axial movement in the hub due to clearance in the bearings

J. Packing bearings--Process of cleaning the old grease from bearings and then forcing new wheel bearing grease into the openings between the races and the ball or roller cages

K. Brinelling--Notch in the race caused by improper installation of bearings

II. Types of front wheel bearings (Transparency 2)

A. Tapered roller bearing

(NOTE: This is the most common type used.)

B. Ball bearing

INFORMATION SHEET

III. Parts of a tapered roller front wheel bearing assembly (Transparency 3)

- A. Hub

  (NOTE: The hub supports the brake drum or rotor assembly.)

- B. Outer bearing cup
- C. Outer bearing cone
- D. Thrust washer
- E. Adjusting nut
- F. Nut lock
- G. Cotter pin
- H. Grease cap
- I. Inner bearing cup
- J. Inner bearing cone
- K. Grease seal
- L. Spindle

IV. Characteristics of quality wheel bearing grease

- A. Water resistant
- B. Heat resistant

  (NOTE: The grease will not lose its viscosity as temperature rises.)

- C. High temperature stability

  (NOTE: The grease will not separate at elevated temperatures.)

- D. Good mechanical and chemical stability

  (NOTE: The grease will retain an adhesive effect to metal and will not form acids under adverse conditions.)

V. Precautions to observe while packing wheel bearings

- A. Do not mix old and new grease or greases of different base material
- B. Keep bearings and grease clean

566 – 576

INFORMATION SHEET

C. Handle bearings with care to avoid bending the cage or chipping the rollers or races

D. Do not drag the hub over the spindle

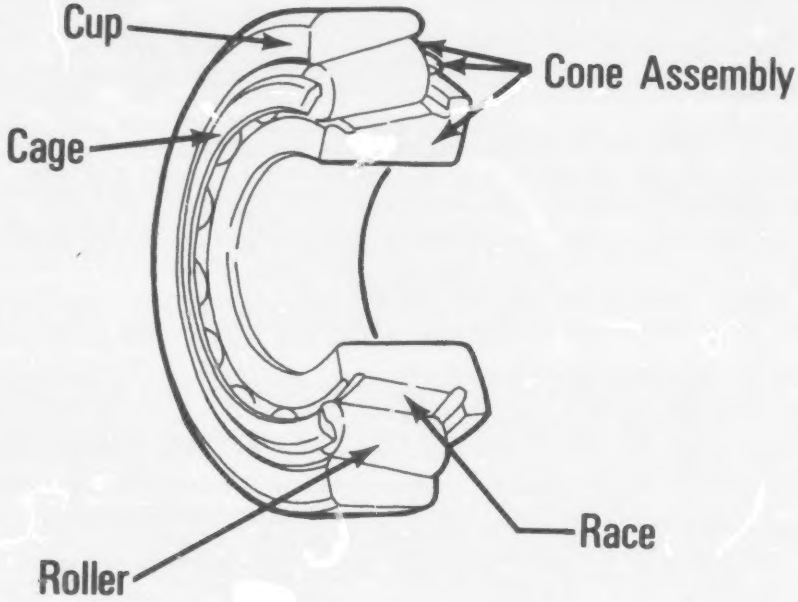
E. Do not spin the bearings when drying with compressed air

F. Replace worn or defective grease seals

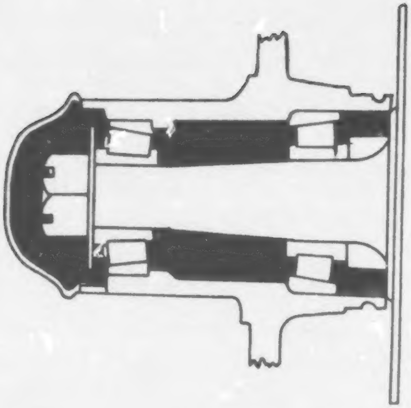
G. Use new cotter pins

H. Inspect for defective bearings

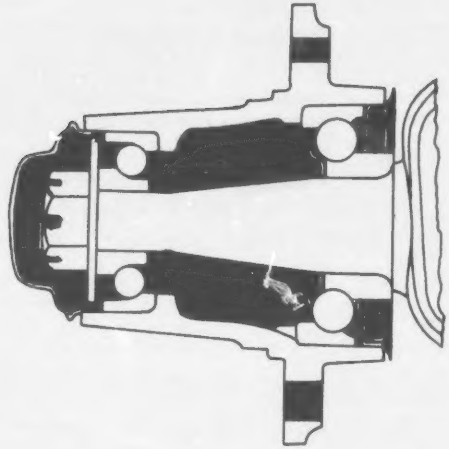
Parts of a Tapered Roller Front Wheel Bearing


Cup
Cone Assembly
Cage
Race
Roller

Types of Front Wheel Bearings

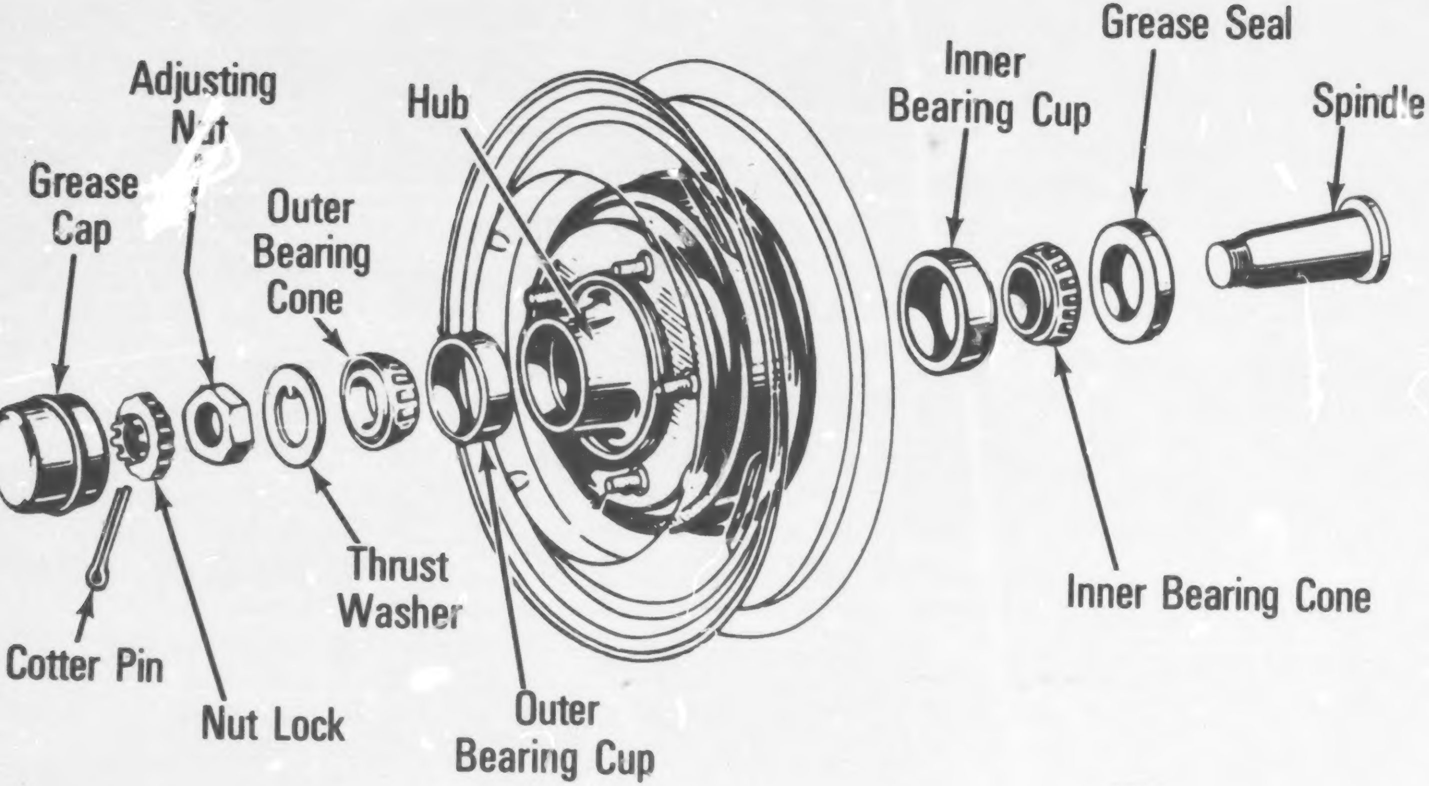


Tapered
Roller Bearing



Ball Bearing

Parts of a Tapered Roller Front Wheel Bearing Assembly


Grease Seal
Inner Bearing Cup
Spindle
Adjusting Nut
Hub
Grease Cap
Outer Bearing Cone
Thrust Washer
Inner Bearing Cone
Cotter Pin
Nut Lock
Outer Bearing Cup

WHEEL BEARINGS
UNIT I

JOB SHEET #1--CLEAN AND INSPECT A BEARING

I. Tools and materials

  A. Variety of bearings

  B. Cleaning solvent

  C. Parts cleaning brush

  D. Shop towels

  E. Light oil

  F. Source of clean compressed air

II. Procedure

  A. Clean the bearing with cleaning solvent and brush

    1. Dip the bearing in solvent while brushing it

    2. Rotate the bearing slowly to aid in cleaning all surfaces

  B. Dry the bearing with clean compressed air

  (CAUTION: Do not spin the bearing with air; the bearing could be damaged and the technician could be injured.)

  C. Dip the clean bearing in light oil or grease immediately to prevent oxidation of the metal

  (NOTE: A little tarnish or stain on the edges of the raceway is not harmful to bearing operation.)

  D. Inspect the bearing

    1. Hold the bearing so that the inner raceway is visible; rotate slowly and inspect for brinelling, scores, or irregular wear patterns

    2. Check the inner race for cracks or chips on the outer surfaces

    3. Hold the bearing so that the outer raceway is visible; rotate slowly and inspect for brinelling, scoring, or irregular wear patterns

JOB SHEET #1

4. Inspect bearing for overheating, which is indicated by a brownish blue or blue black color
5. Inspect for flaked, pitted, or scratched areas on ball or rollers
6. Inspect roller or ball cage for excessive looseness or broken or bent condition

(NOTE: If any of these conditions exist, replace the bearing.)

WHEEL BEARINGS
UNIT I

JOB SHEET #2--ADJUST FRONT WHEEL BEARINGS

I. Tools and equipment

   A. Foot pound torque wrench

   B. Inch pound torque wrench

   C. Sockets, 1/2" drive, 15/16" - 1 1/4" (23 mm - 31 mm)

   D. Diagonal cutting pliers

   E. Grease cap remover

   F. New cotter pins

   G. Floor jack

   H. Jack stands

   I. Channel-lock pliers or adjustable end wrench

   J. Rubber mallot

   K. Hub cap remover

II. Procedure for adjusting wheel bearings with torque wrench

   A. Raise the vehicle and place on jack stands

   B. Remove wheel cover

   C. Remove grease cap

      (CAUTION: When removing the left front grease cap, use care to avoid damage to the speedometer drive connection on some models.)

   D. Remove the cotter pin

   E. Remove the adjusting nut lock if so equipped

   F. Seat the bearings by torqueing the adjusting nut to 15 foot pounds (1.054 kg/cm^2) while spinning the tire in a forward rotation

      (CAUTION: Rotate the tire and hub assembly while tightening the adjusting nut to allow the bearings to align.)

JOB SHEET #2

G. Back off the adjusting nut approximately 1/2 turn

H. Retorque the adjusting nut to 25 inch pounds (0.140 kg/cm^2)

I. Replace adjusting nut lock so that one of the slots aligns with the spindle hole

J. Loosen the adjusting nut one slot on the nut lock

(NOTE: The bearing should have 0" - 0.005" [0 - 0.1270 mm] end play with no preload.)

K. Install a new cotter pin

(NOTE: The cotter pin should be large enough in diameter to completely fill the hole in the spindle. The ends should bend so they will not extend past the end of the spindle.)

L. Replace grease cap

M. Replace wheel cover

N. Lower vehicle to the floor

III. Procedure for adjusting front wheel bearings without torque wrench

A. Raise the vehicle and place on jack stands

B. Remove wheel cover

C. Remove grease cap

D. Remove cotter pin

E. Hand spin wheel

F. Tighten adjusting nut with wrench to fully seat the bearings and to overcome any burrs on the threads

G. Back off adjusting nut approximately 1/2 turn

H. Hand tighten the adjusting nut

I. Loosen adjusting nut until a hole in the spindle aligns with the nearest slot in the nut lock

(NOTE: When the bearing is properly adjusted, there will be 0" to 0.005" [0 - 0.1270 mm] end play in the bearings.)

JOB SHEET #2

J. Install a new cotter pin

K. Replace grease cap

L. Replace wheel cover

M. Lower vehicle to the floor

(CAUTION: Wheel bearings must never be preloaded; this can result in premature bearing failure.)

WHEEL BEARINGS
UNIT I

JOB SHEET #3--PACK A FRONT WHEEL BEARING ASSEMBLY

I. Tools and equipment

- A. Grease cap remover
- B. Diagonal cutters
- C. Adjustable wrench, 10"
- D. Torque wrench as required
- E. Adjusting nut socket
- F. Ball peen hammer, 16 oz (.45 kg)
- G. Grease seal driver
- H. Soft steel drift
- I. Nonmetallic rod, 3/4" (19 mm) diameter
- J. Bearing packer
- K. Wheel bearing grease

II. Procedure

- A. Raise the vehicle and support on jack stands
- B. Remove the wheel cover
- C. Remove the grease cap
- D. Remove the cotter pin and nut lock
- E. Remove the adjusting nut and thrust washer
- F. Pull out slightly on the tire and push it back in to unseat the outer bearing cone; remove the cone
- G. Remove the wheel and hub from the spindle

  (NOTE: The procedure to follow will be determined by the type of brakes, either drum or disc.)

  1. Drum brake models

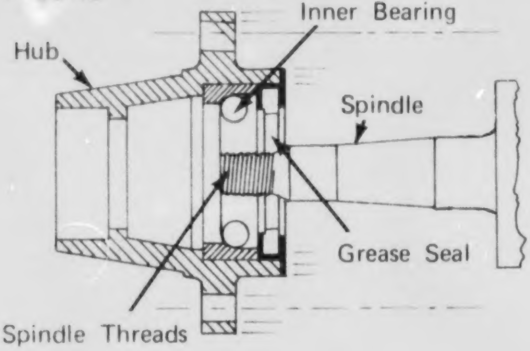
     a. Back off brake shoe adjustment if necessary

JOB SHEET #3

b. Slide wheel, hub, and drum assembly off spindle

(CAUTION: Support the weight of the wheel to prevent damage to the inner bearing and grease seal. See Figure 1.)

FIGURE 1


Inner Bearing
Hub
Spindle
Grease Seal
Spindle Threads

2. Disc brake models

a. Remove the tire and wheel assembly from the hub

b. Remove the brake caliper assembly from over the rotor (Figure 2a or 2b)

FIGURE 2a

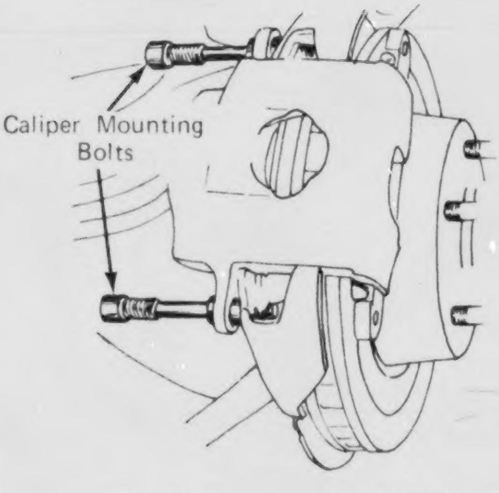
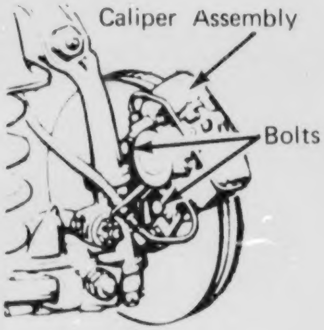

Caliper Mounting Bolts

FIGURE 2b


Caliper Assembly
Bolts

(CAUTION: Do not let the weight of the caliper hang on the brake hose.)

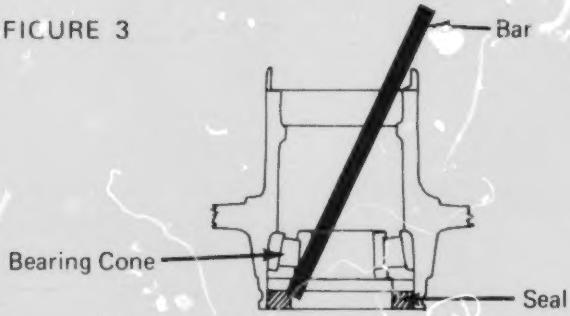
c. Slide the hub and rotor assembly off the spindle

JOB SHEET #3

H. Remove the grease seal from the hub by driving it out with a nonmetallic rod (Figure 3)

(NOTE: A heel bar may be used to pull the seal.)

FIGURE 3


Bar
Bearing Cone
Seal

I. Remove the inner bearing cone

J. Clean the bearing cones, washers, adjusting nuts, and nut locks with clean kerosene, mineral spirits, or other similar cleaning fluids

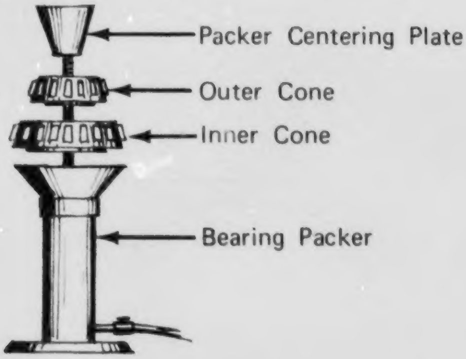
K. Air dry all parts

(CAUTION: Do not spin the bearing cones; it will damage the bearing and create physical danger to all persons in that area.)

L. Examine bearing cones for pitting or brinell marks; rollers and cone flange should be free from chips or other damage

M. Place the clean, dry bearing cones for one wheel in the bearing packer (Figure 4)

FIGURE 4

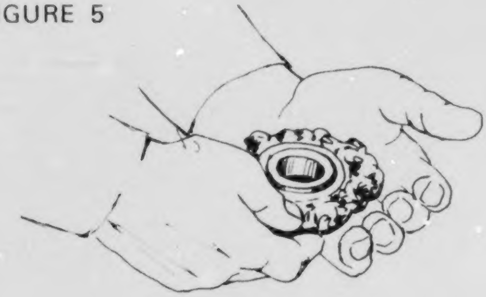

Packer Centering Plate
Outer Cone
Inner Cone
Bearing Packer

JOB SHEET #3

N. Force the grease through the cones slowly enough to observe when the bearing cage is completely filled

(NOTE: If a bearing packer is not available, force the grease through the bearing cage by hand. See Figure 5.)

FIGURE 5

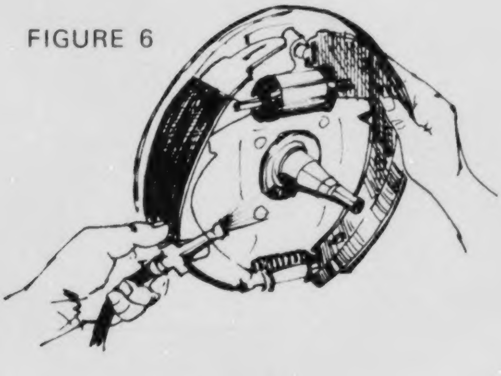


O. Remove the cones from the packer; coat the outside of the cage and rollers with grease approximately 1/4" (6.35 mm) deep

(NOTE: Keep the packed cones in a clean place and covered until they are needed.)

P. Blow the dust from the brake assembly with compressed air (Figure 6)

FIGURE 6

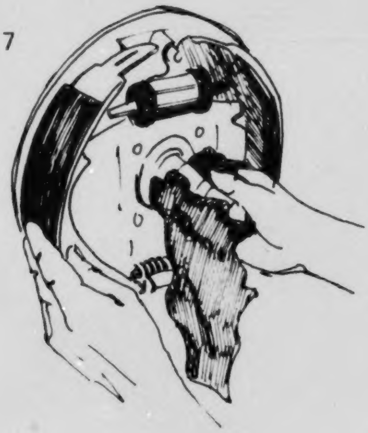


(CAUTION: Avoid getting grease or other contamination on brake shoe lining.)

JOB SHEET #3

Q. Wipe the spindle clean and inspect the threads and cone seat areas for damage or wear (Figure 7)

FIGURE 7



R. Coat the spindle with a thin film of grease

S. Clean the hub with kerosene, mineral spirits, or other similar cleaning fluids

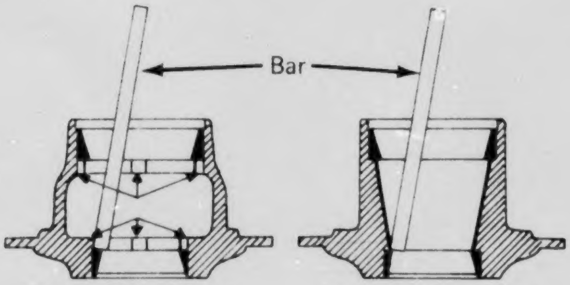
T. Dry the hub with compressed air and inspect the bearing cups for pitting, scoring, or loose fit

U. Replace bearing cups if necessary

1. Drive the cup out with a soft steel drift

   (NOTE: The hub seat for the bearing is cut away in areas to allow the drift to contact the bearing cup. See Figure 8.)

FIGURE 8

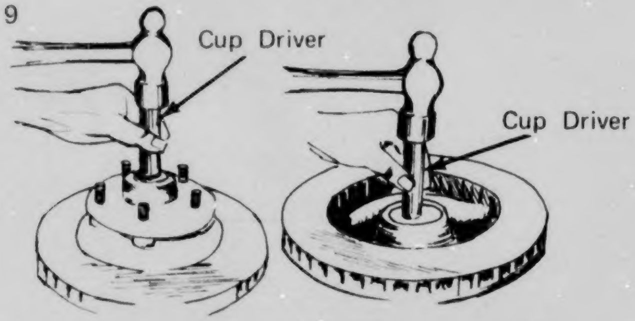


Hub With Slots Hub Without Slots

JOB SHEET #3

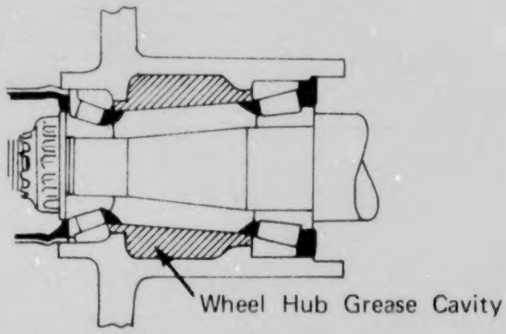
2. Align the new cup squarely with the hub; drive it in with a driving tool or soft steel dritt (Figure 9)

FIGURE 9



V. Coat the inside of the hub cavity with grease (Figure 10)

FIGURE 10



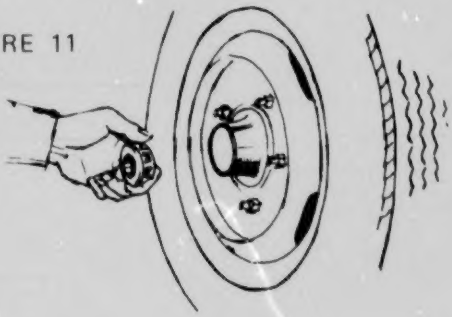
W. Place the inner bearing cone in hub, small end first

X. Install seal with the lip facing inward; use a seal driver to drive the seal flush with the end of the hub

Y. Place the hub assembly on the spindle

Z. Install the outer bearing cone on the spindle; slide it into the bearing cup while holding the hub in alignment (Figure 11)

FIGURE 11



JOB SHEET #3

AA. Install thrust washer and adjusting nut; tighten nut while rotating the hub to permit the bearing to align

BB. Adjust the bearing

CC. Replace the grease cap

DD. Install the disc brake caliper or brake drum as required

EE. Replace the tire and wheel assembly if removed

FF. Replace the wheel cover

GG. Readjust the brakes as necessary

(NOTE: On disc brakes the brake pedal should be pumped several times to regain pad height; then brake fluid level should be checked.)

HH. Lower the vehicle to the floor

II. Road test with the instructor

WHEEL BEARINGS
UNIT I

TEST

1. Match the terms on the right to the correct definitions.

_____a. Process of cleaning the old grease from bearings and then forcing new wheel bearing grease into the openings between the races and the ball or roller cages

_____b. Part of the bearing which contains the outer race; installed in the hub with a press fit

_____c. Adjustment of antifriction bearings so that they will work under mild pressure

_____d. Installation of a bearing cup with a tight or interference fit requiring more than hand force to install

_____e. Bearing containing rollers or balls plus an inner and outer race that allows the load to roll on the balls or rollers thus minimizing friction

_____f. Installation of a bearing cone with a light fit that can be installed with hand pressure

_____g. Very slow, steady rotation of a push fit bearing race to keep changing the area of greatest load and thus increase bearing life

_____h. Surface of the groove or path on which the balls or rollers of a bearing roll

_____i. Amount of axial movement in the hub due to clearance in the bearings

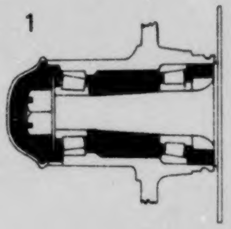
_____j. Part of the roller bearing which contains the inner race, roller cage, and rollers; installed on the spindle with a push fit

_____k. Notch in the race caused by improper installation of bearings

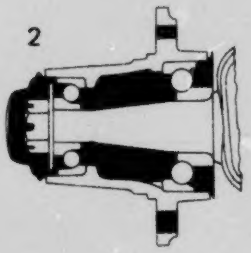
1. Antifriction bearing
2. Press fit
3. Push fit
4. Bearing creep
5. Preload
6. End play
7. Packing bearings
8. Bearing race
9. Bearing cone
10. Brinelling
11. Bearing cup

2. Identify the types of front wheel bearings illustrated below by placing the correct numbers in the blanks provided.

1



2



_____a. Ball bearing

_____b. Tapered roller bearing

3. Identify the parts of the tapered roller front wheel bearing assembly in the diagram below by placing the correct numbers in the blanks provided.

_____a. Spindle

_____b. Inner bearing cup

_____c. Adjusting nut

_____d. Grease cap

_____e. Outer bearing cup

_____f. Hub

_____g. Thrust washer

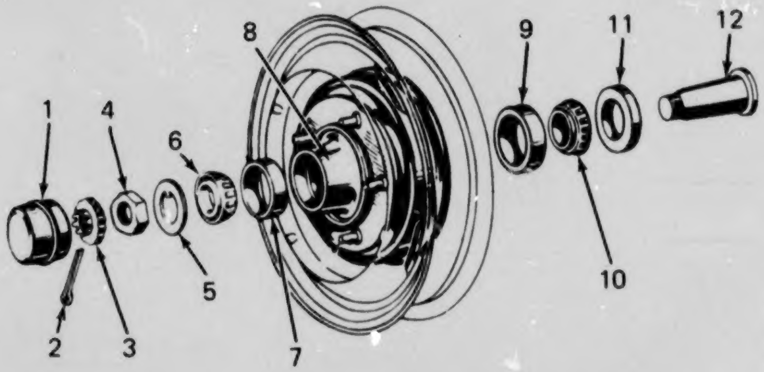
_____h. Grease seal

_____i. Outer bearing cone

_____j. Nut lock

_____k. Cotter pin

_____l. Inner bearing cone



4. List four characteristics of quality wheel bearing grease.

   a.

   b.

   c.

   d.

5. State five precautions to observe while packing wheel bearings.

   a.

   b.

   c.

   d.

   e.

6. Demonstrate the ability to:

   a. Clean and inspect a bearing.

   b. Adjust front wheel bearings.

   c. Pack a front wheel bearing assembly.

   (NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

WHEEL BEARINGS
UNIT I

ANSWERS TO TEST

1. a. 7
   b. 11
   c. 5
   d. 2
   e. 1
   f. 3
   g. 4
   h. 8
   i. 6
   j. 9
   k. 10
2. a. 2
   b. 1
3. a. 12
   b. 9
   c. 4
   d. 1
   e. 7
   f. 8
   g. 5
   h. 11
   i. 6
   j. 3
   k. 2
   l. 10
4. a. Water resistant
   b. Heat resistant
   c. High temperature stability
   d. Good mechanical and chemical stability
5. Any five of the following:
   a. Do not mix old and new grease or greases of different base material
   b. Keep bearings and grease clean
   c. Handle bearings with care to avoid bending the cage or chipping the rollers or races
   d. Do not drag the hub over the spindle

   e. Do not spin the bearings when drying with compressed air

   f. Replace worn or defective grease seals

   g. Use new cotter pins

   h. Inspect for defective bearings

6. Performance skills evaluated to the satisfaction of the instructor

TIRES AND WHEELS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to state the basic functions of tires; identify the types of tire construction, abnormal tire wear patterns, and tire size markings; and demonstrate the ability to perform tire maintenance. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with tires and wheels to the correct definitions.
2. State the basic functions of tires.
3. Name the basic types of tires.
4. Identify the parts of a tire.
5. Describe the ways in which tire plies are laid.
6. Complete a chart by writing the correct cord type when given the tensile strength and advantages.
7. Identify abnormal tire tread wear patterns.
8. Identify tire size markings.
9. Complete a chart by writing the correct load range when given the ply rating.
10. Discuss tire inflation pressure.
11. List reasons for periodic tire rotation.
12. Draw tire rotation patterns.
13. List methods of repairing minor tire punctures.
14. Identify types of wheels.
15. Identify the parts of a drop center wheel.

16. Demonstrate the ability to:

    a. Remove, inspect, and replace a tire on a wheel.

    b. Repair a tire puncture.

TIRES AND WHEELS
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Collect tools and materials necessary for demonstrating job sheets.

   E. Discuss unit and specific objectives.

   F. Discuss information sheet.

   G. Demonstrate and discuss procedures outlined in the job sheets.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Demonstrate the ability to accomplish the procedures outlined in the job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Basic Types of Tires

      2. TM 2--Parts of a Tire

   3. TM 3--Methods of Laying Tire Plies
   4. TM 4--Abnormal Tire Tread Wear Patterns
   5. TM 5--Late Tire Size Markings
   6. TM 6--Early Tire Size Markings
   7. TM 7--Tire Load Range Rating System
   8. TM 8--Tire Inflation Pressure
   9. TM 9--Tire Rotation Patterns
   10. TM 10--Methods of Tire Puncture Repair
   11. TM 11--Types of Wheels
   12. TM 12--Parts of a Drop Center Wheel
   13. TM 13--Tire Valve Stem and Valve Core

D. Job sheets

   1. Job Sheet #1--Remove, Inspect, and Replace a Tire on a Wheel
   2. Job Sheet #2--Repair a Tire Puncture

E. Test

F. Answers to test

II. References:

A. Snyder, Al. *Tire Guide.* Vol. 18. Farmingdale, New York: Bennett Garfield Publisher, 1975.

B. Crouse, William H. *Automotive Mechanics.* 7th ed. New York: McGraw-Hill Book Co., 1975.

C. *Chevrolet Service Manual.* Detroit, Michigan: Chevrolet Motor Div./General Motors Corp., 1975.

D. *Chrysler, Plymouth, Dodge Service Manual.* Detroit, Michigan: Chrysler Corp., 1975.

E. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1971.

F. Bacon, E. Miles. *Principles of Wheel Alinement Service.* New York: McGraw-Hill Book Co., 1971.

TIRES AND WHEELS
UNIT II

INFORMATION SHEET

I. Terms and definitions

   A. Tire tread--Area of the tire that contacts the road

   B. Tire bead--That portion of the tire that bears against the rim flange and consists of a number of turns of steel wire to provide greater strength

   C. Tire casing--Main body of the tire exclusive of the tread

   D. Tire ply--Layer of cord impregnated with rubber and shaped to form the body of the tire

   E. Bias ply--Body ply that is laid on a bias (30° - 60° angle) from bead to bead with the cord angle reversed on alternating plies

   F. Radial ply--Body ply that is laid at a 90° angle from bead to bead

      (NOTE: The "R" in the tire size marking indicates the tire is radial ply.)

   G. Stabilizer belt--Ply applied directly beneath the tire tread and parallel to the tread

   H. Vulcanizing--Process of heating rubber under pressure to give shape and desired characteristics to the tire

   I. Tire separation--Bulge on a tire where air has penetrated through the body plies and separated the sidewall or tread from the outer ply

   J. Tire tread wear indicator--One-half inch (12.7 mm) wide bands across the tread that appears when tread depth is reduced to 1/16 inch (1.587 mm)

   K. Tire and wheel runout--How true the tire or wheel rotates with respect to lateral movement and radial movement

   L. Drop center wheel--Rim that has a broad groove or "dropped" area in its center to allow the removal of the tire

INFORMATION SHEET

M. Tire size range--Prefix letter of the tire size markings located on the tire sidewall; refers to the vehicle body size (compact, intermediate, and full-size) that the tire is designed to fit (Transparency 5)

(NOTE: Tire size range letters are A, B, C, D, E, F, G, H, J, K, L, M, and N.)

N. Tire load range--System that replaces the ply system for indicating weight-carrying capacity of a tire (Transparency 7)

(NOTE: Load range specifications are set by the U.S. Department of Transportation.)

O. Aspect ratio--Ratio of tire height to tire width (Transparency 5)

(NOTE: It consists of ratios of 83, 80, 78, 70, 60, and 50.)

P. Rim diameter--Diameter of the wheel from tire bead seat to tire bead seat

Q. Valve stem--Rubber tube mounted in the rim or attached to the inner tube to provide a way to inflate or deflate the tire (Transparency 13)

R. Valve core--Check valve installed in the valve stem that allows air to enter the tire or tube but prevents air from escaping (Transparency 13)

S. Inner tube--Air-tight rubber tube placed inside the casing of a pneumatic tire to hold air under pressure

T. Tubeless tire--Tire that seals to the rim with sealing grooves on the tire bead area and seals the casing with a soft rubber inner surface, eliminating the need for an inner tube

(NOTE: Snap-on valve stems are used on tubeless tires.)

II. Basic functions of a tire

A. Absorb the shock of irregular road surfaces

B. Provide good traction between the road and the wheel

III. Basic types of tires (Transparency 1)

A. Tube

B. Tubeless

INFORMATION SHEET

IV. Parts of a tire (Transparency 2)

- A. Tread
- B. Undertread
- C. Casing plies
- D. Inner liner
- E. Fillers
- F. Bead wrapping
- G. Bead wires
- H. Rubber chafer
- I. Wall rubber

V. Methods of laying plies in the tire (Transparency 3)

- A. Radial ply--The casing plies are laid at right angles to the circumference of the tire
- B. Bias ply--The casing plies are laid on the bias or crisscross at an angle of 30° to 38°
- C. Belted ply--Additional plies are added directly under the tire tread

  (NOTE: Belted plies can be an added feature on either radial or bias ply tires.)

VI. Tensile strength and advantages of tire cords

Cord Type	Tensile Strength, PSI	Advantages
A. Rayon	94,000 psi (6608.95 kg/cm^2)	Soft ride, resilient, inexpensive
B. Polyester	104,000 psi (7322.03 kg/cm^2)	Soft ride, more heat resistant, inexpensive
C. Nylon	122,000 psi (8577.57 kg/cm^2)	High heat resistance, excellent impact resistance, minimum flex, water repellent
D. Fiberglass	407,000 psi (28,615.35 kg/cm^2)	Greatest strength, soft ride

INFORMATION SHEET

VII. Abnormal tire tread wear patterns (Transparency 4)

A. Toe-in wear

(NOTE: A tapered or feathered edge on the tire tread causes the tire to drag instead of rolling true.)

B. Camber wear

(NOTE: One side of the tire tread wears faster than the other because the tire runs at an angle to the road.)

C. Underinflation wear

(NOTE: Both shoulders of the tread wear much faster than the center.)

D. Overinflation wear

(NOTE: There is faster wear of the center of the tread and an increased possibility of cuts, punctures, and bruises.)

E. Cornering wear

(NOTE: A diagonal abrasive wear on the outside edge of the tread is caused by the tire skidding and tending to roll while cornering at excessive speeds.)

F. Multi-problem wear

Examples: Bald spot, cup, or scallop

(NOTE: Multi-problem tire wear occurs on vehicles that are driven mostly at highway speed without the recommended tire rotation, proper wheel balance, proper alignment, or tight suspension parts.)

VIII. Tire size markings

(NOTE: Some foreign-made tires have the width of the tire designated in millimeters, such as **185** R 14.)

A. Late marking system (Transparency 5)

1. Size range
2. Radial ply
3. Aspect ratio
4. Rim diameter in inches

B. Early marking system (Transparency 6)

1. Tire height in inches
2. Rim diameter in inches

INFORMATION SHEET

IX. Tire load range rating system (Transparency 7)

Load Range	Tire Ply Rating
B	2 ply with 4 ply rating; 4 ply
C	6 ply
D	4 ply with 8 ply rating; 8 ply

(NOTE: Load capacity for a B range tire is the same as a C range tire with the same inflation pressure, but the C range tire can be safely inflated to a higher pressure.)

X. Tire inflation pressure (Transparency 8)

A. Tire pressure should be checked when cold

(NOTE: A tire is considered cold when it has sat for three hours and has not been driven over one mile after that three hour period.)

B. Tire pressure should be the same as the vehicle manufacturer's specifications

C. Tire pressure may vary from vehicle specifications only to correct tire wear due to inflation pressures

(CAUTION: Do not exceed the maximum pressure and load indicated on the tire sidewall.)

D. Tire pressure should be checked each month or sooner if inspection indicates a low condition

XI. Reasons for periodic tire rotation

A. Equalizes tire wear

B. Minimizes the possibility of tire noise

C. Allows for close tire inspection

XII. Tire rotation patterns (Transparency 9)

A. Bias-ply tires

1. Five tire rotation

2. Four tire rotation

INFORMATION SHEET

   B. Radial ply tires

      1. Five tire rotation

      2. Four tire rotation

XIII. Methods of repairing minor tire punctures (Transparency 10)

   A. Hot patch

   B. Cold patch

   C. Rubber plug

XIV. Types of wheels (Transparency 11)

   A. Drop center

   (NOTE: This type of wheel is used on most passenger cars.)

   B. Split rim

      1. Two piece

      2. Three piece

   (NOTE: These rims are used on heavy duty applications. Tubes are required because the rim cannot be made airtight.)

   (CAUTION: Be sure all air is out of the tire before starting to remove the tire. Always safety chain or confine the tire and rim assembly while inflating the tire. If the lock on the rim comes loose, it could seriously injure or kill anyone nearby.)

XV. Parts of drop center wheel (Transparency 12)

   A. Center section

   B. Flange

   C. Tire bead seat area

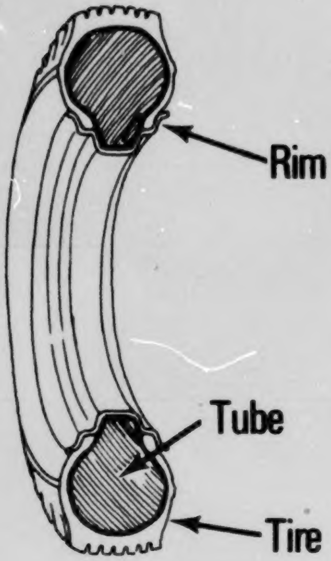
   D. Drop center area

   E. Safety ridge

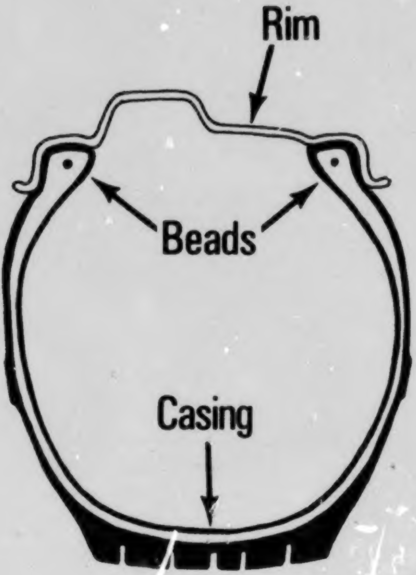
   F. Mounting hole

   G. Rivet

Basic Types of Tires

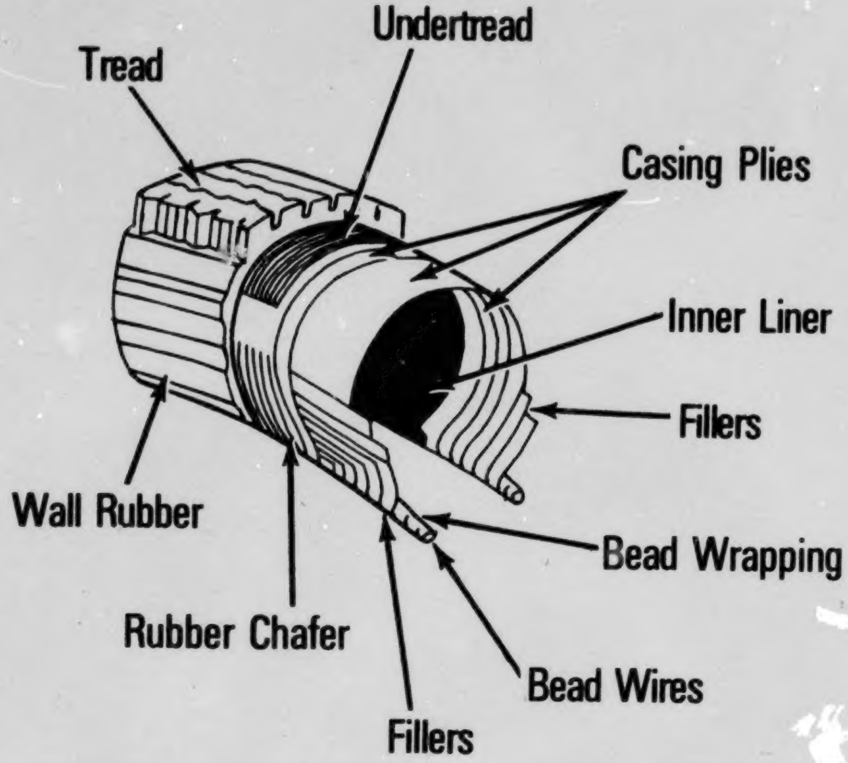

Rim
Tube
Tire

Tube

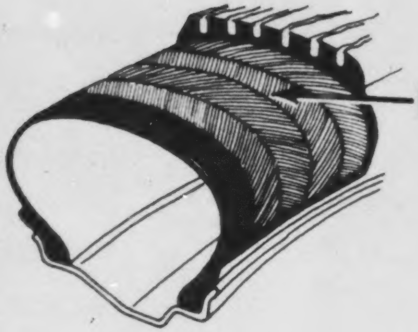

Rim
Beads
Casing

Tubeless

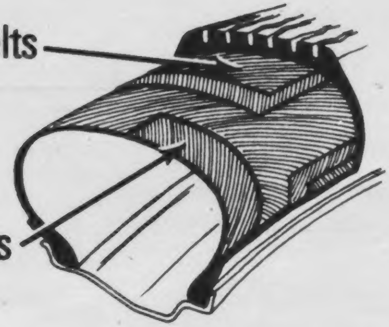
Parts of a Tire


Undertread
Tread
Casing Plies
Inner Liner
Fillers
Wall Rubber
Bead Wrapping
Rubber Chafer
Bead Wires
Fillers

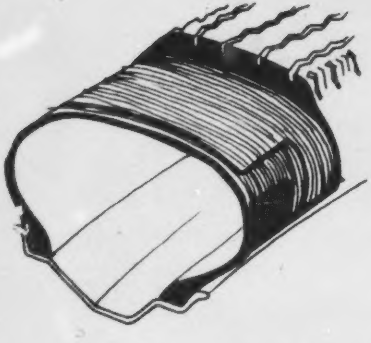
Methods of Laying Tire Plies


Body Ply Cords
Run on Bias

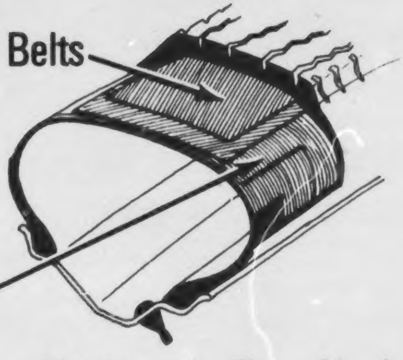
Bias Ply Tire


Stabilizer Belts
Body Ply Cords
Run on Bias

Belted-Bias



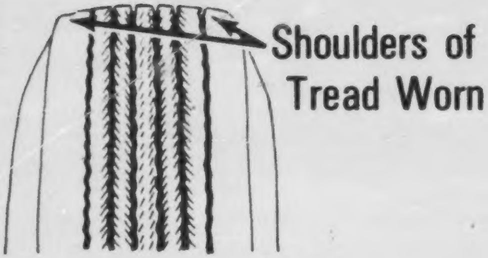
Radial Ply


Stabilizer Belts
Radial Cord
Body Plies

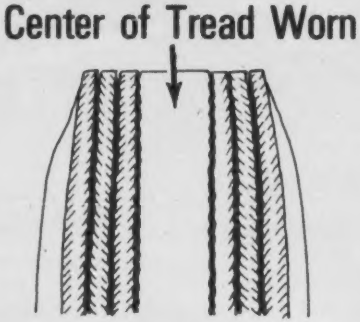
Belted-Radial

AM I - 49-D

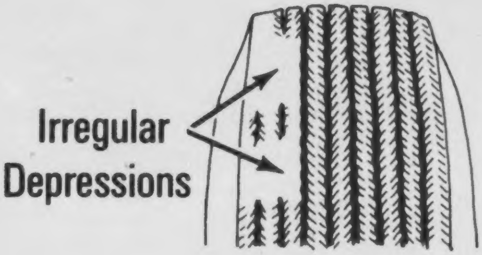
Abnormal Tire Tread Wear Patterns


Shoulders of Tread Worn

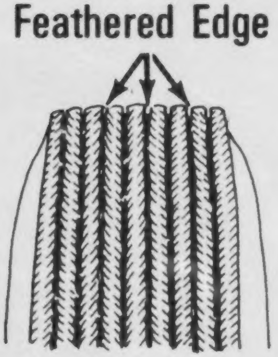
UNDERINFLATION


Center of Tread Worn

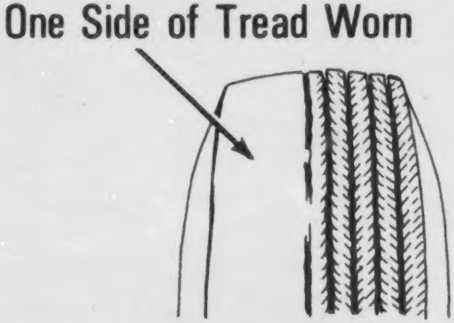
OVERINFLATION


Irregular Depressions

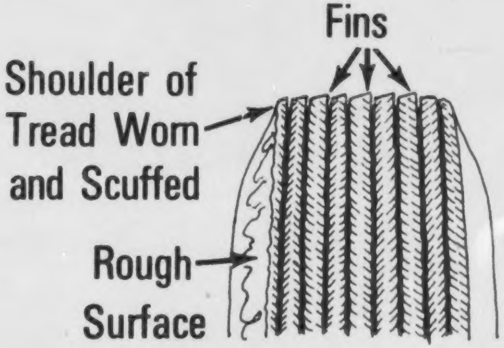
MULTI-PROBLEM


Feathered Edge

TOE-IN WEAR

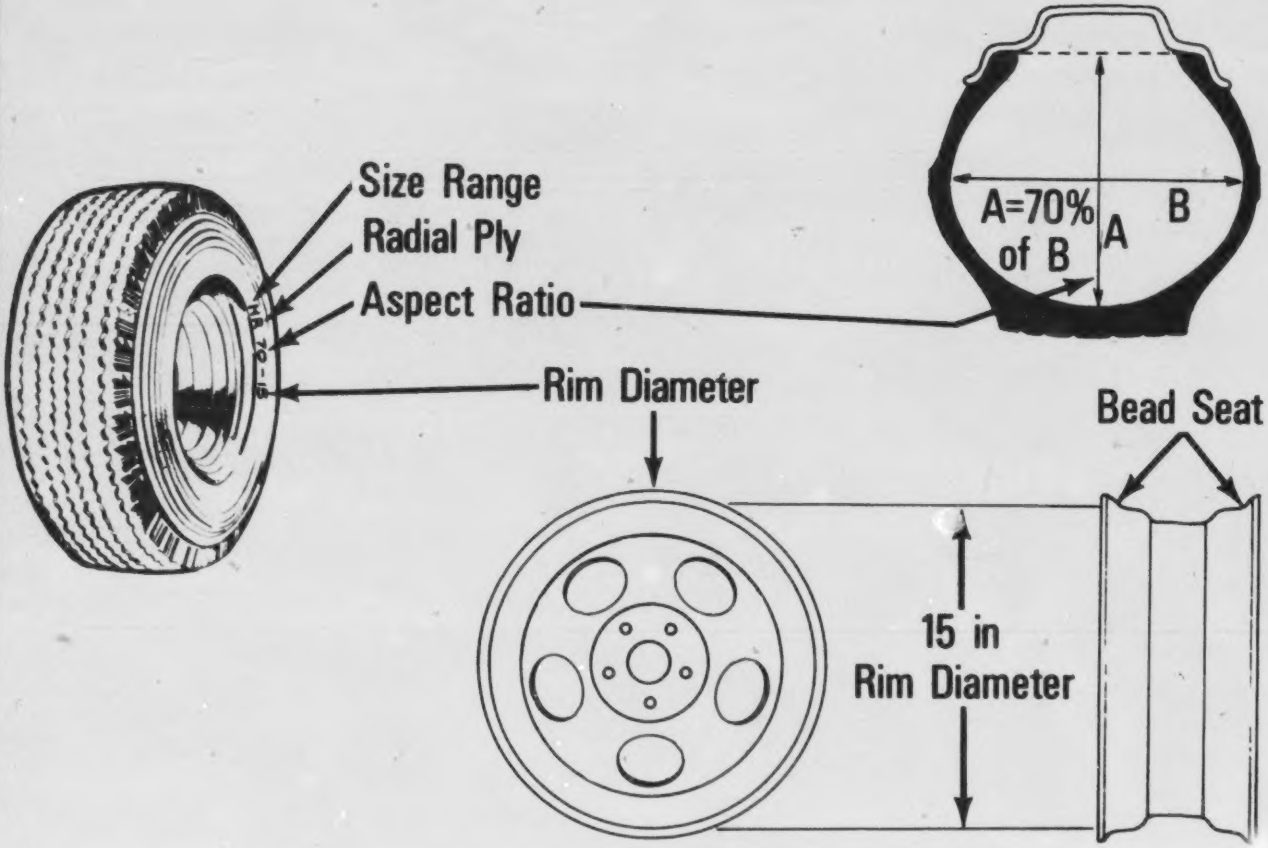

One Side of Tread Worn

CAMBER WEAR

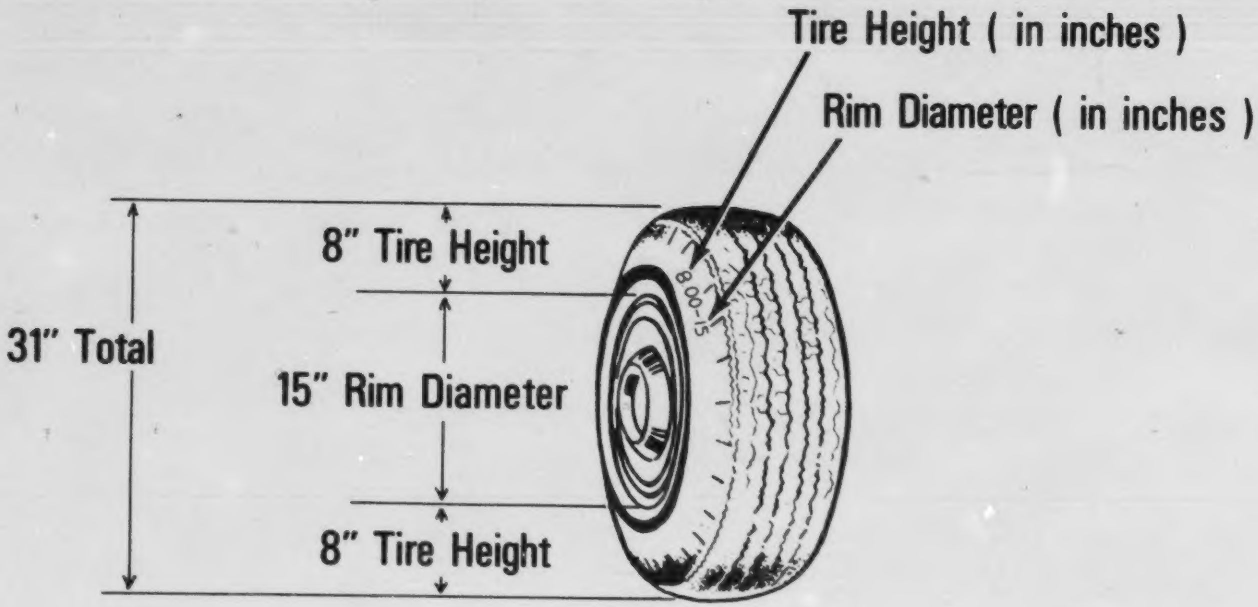

Fins
Shoulder of Tread Worn and Scuffed
Rough Surface

CORNERING WEAR

Late Tire Size Markings

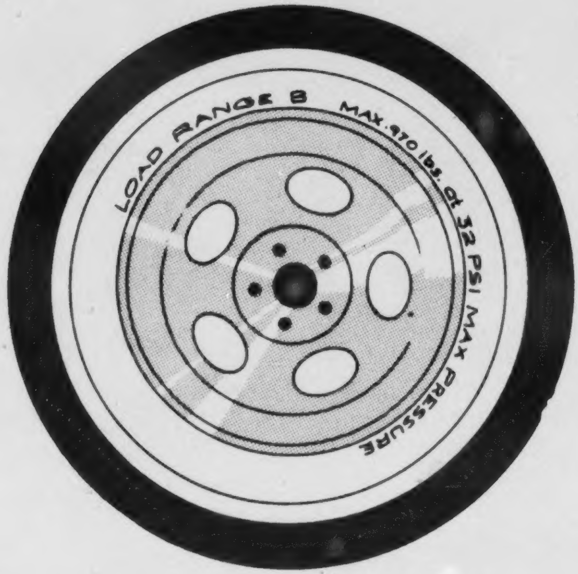

Size Range
Radial Ply
Aspect Ratio
HR 70-15
Rim Diameter
A=70% of B
A
B
Bead Seat
15 in Rim Diameter

Early Tire Size Markings

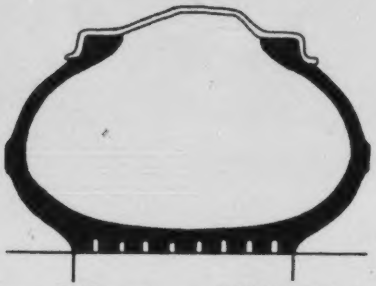

Tire Height (in inches)
Rim Diameter (in inches)
8.00-15
8" Tire Height
31" Total
15" Rim Diameter
8" Tire Height

Tire Load Range Rating System

Load Range	Ply Rating
B	4 Ply and 2 Ply with 4 Ply Rating
C	6 Ply
D	8 Ply and 4 Ply with 8 Ply Rating

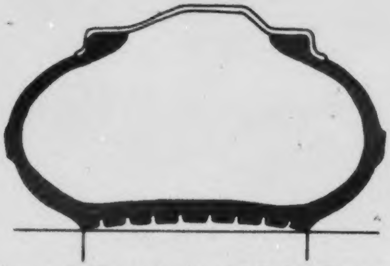

LOAD RANGE B
MAX. 970 lbs. at 32 PSI MAX PRESSURE

Tire Inflation Pressure



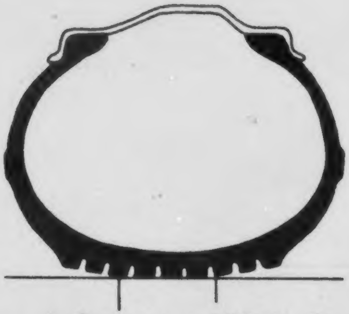
Tread Contact With Road

PROPER INFLATION



Tread Contact With Road

UNDERINFLATION



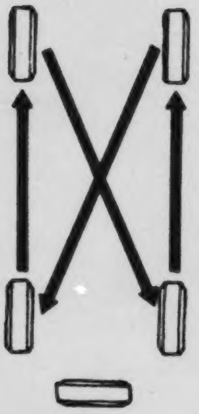
Tread Contact With Road

OVERINFLATION

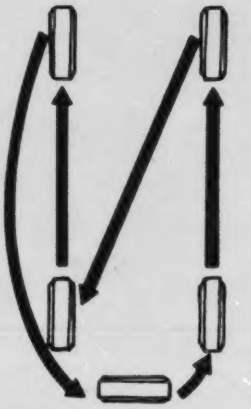
AM I - 59-D

Tire Rotation Patterns

Bias-Ply Tires

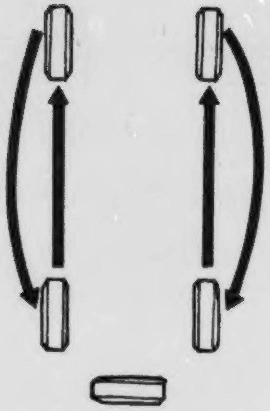


4 Tires

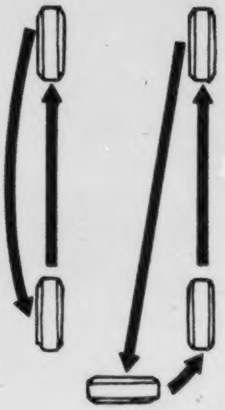


5 Tires

Radial Ply Tires

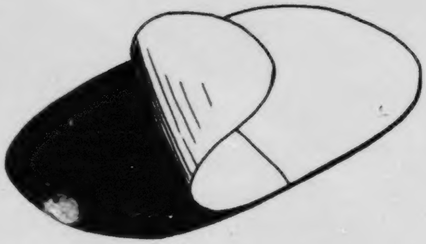


4 Tires

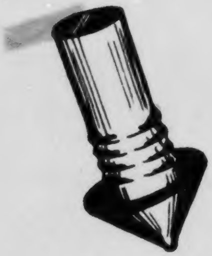


5 Tires

Methods of Tire Puncture Repair

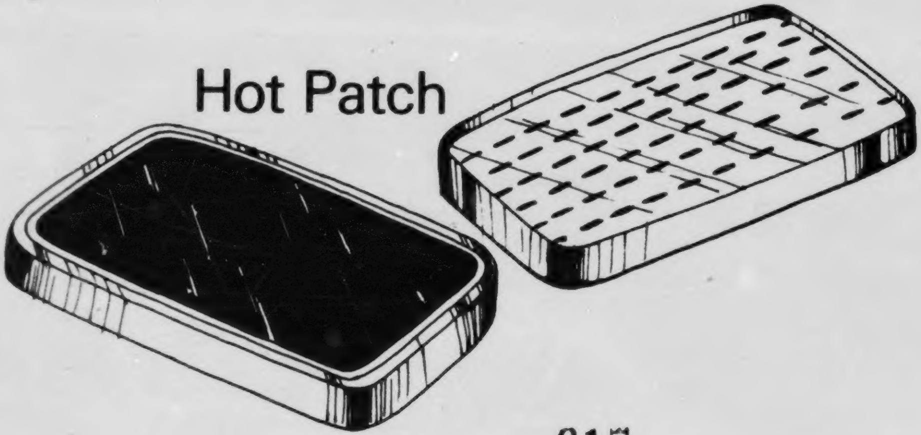


Cold Patch

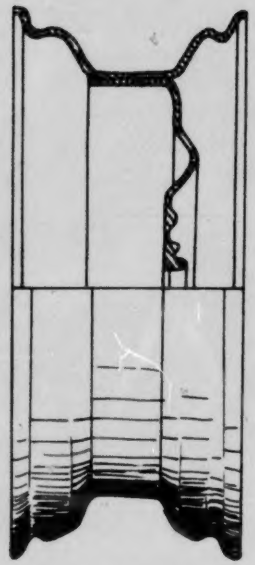


Rubber Plug

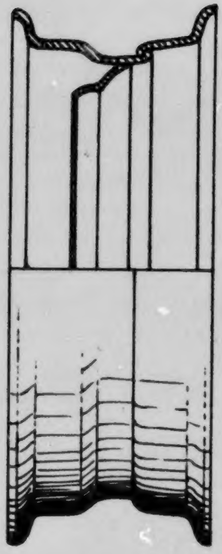
Hot Patch



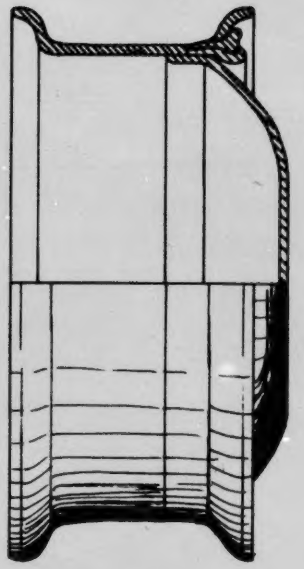
Types of Wheels



Drop
Center Rim



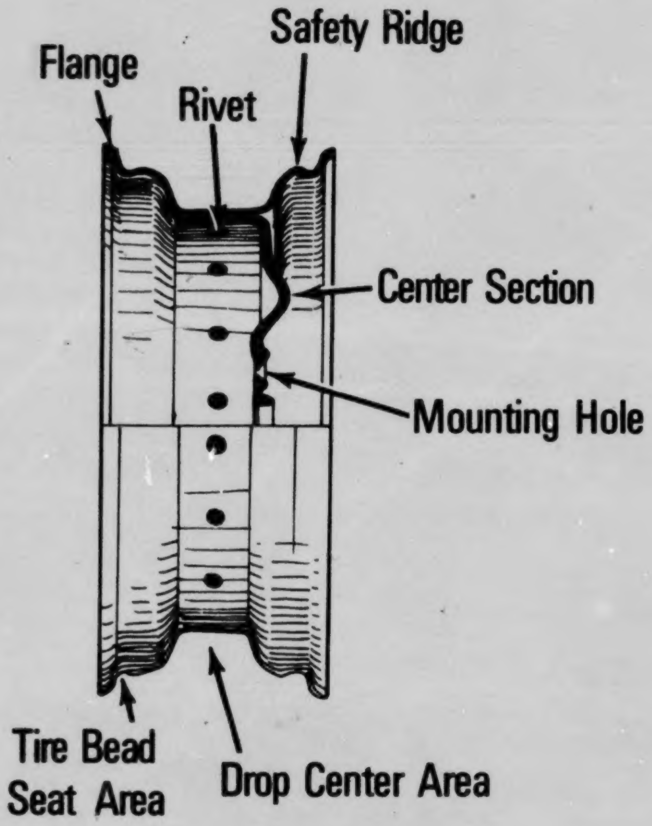
Two Piece
Split Rim



Three Piece
Split Rim

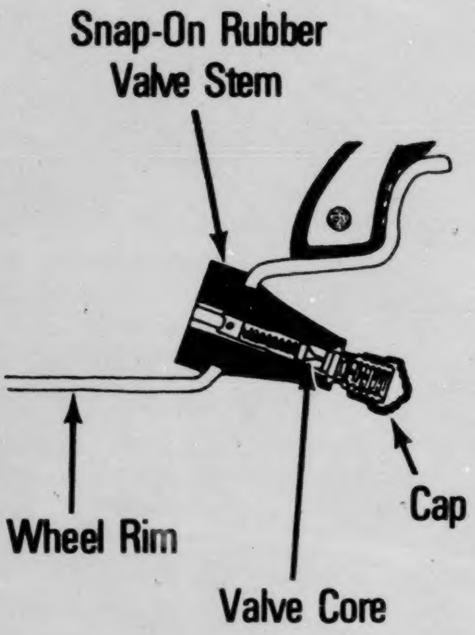
AM I - 65-D

Parts of a Drop Center Wheel

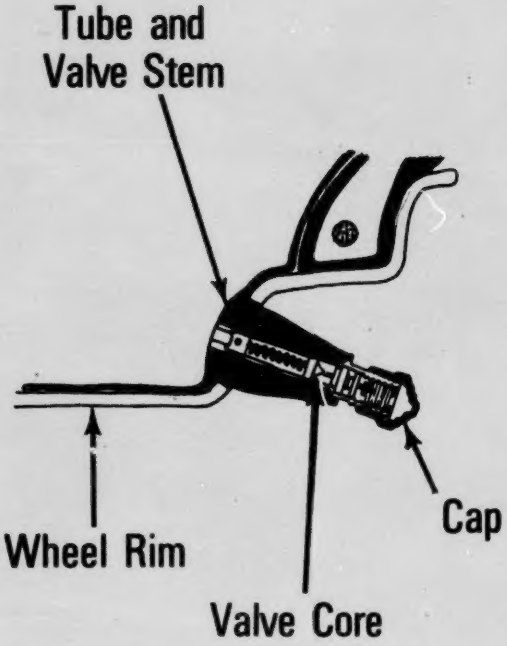

Safety Ridge
Flange
Rivet
Center Section
Mounting Hole
Tire Bead Seat Area
Drop Center Area

AM I - 67-D

Tire Valve Stem and Valve Core


Snap-On Rubber Valve Stem
Wheel Rim
Cap
Valve Core

Tubeless


Tube and Valve Stem
Wheel Rim
Cap
Valve Core

Tube

TIRES AND WHEELS
UNIT II

JOB SHEET #1--REMOVE, INSPECT, AND REPLACE A TIRE ON A WHEEL

I. Tools and equipment

- A. Leak test tank or water and soap solution
- B. Bead expander (for tubeless tires)
- C. Suitable equipment to remove the tire bead from bead seat
- D. Suitable equipment to remove the tire from the wheel
- E. Tire spreader (for repair)
- F. Tire marking crayon
- G. Rubber lubricant with swab
- H. Wire brush

II. Procedure

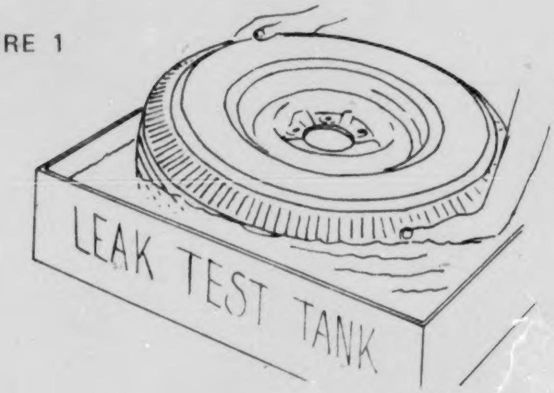
- A. Clean the tire and wheel assembly
- B. Adjust tire inflation to the correct pressure
- C. Inspect the tire visually for punctures, cuts, bruises, or separations

  (NOTE: Mark any problem area with the crayon for further inspection.)
- D. Immerse the tire and wheel assembly in the leak test tank

JOB SHEET #1

E. Check for bubbles that indicate an air leak (Figure 1)

FIGURE 1



(NOTE: A soap solution can be used to detect leaks by spreading it over the surface of the tire. Bubbles will form at the leak.)

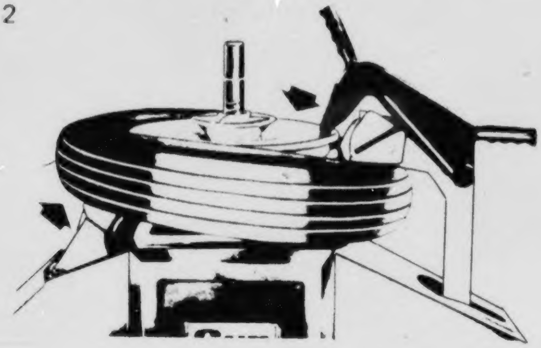
F. Mark leaks with crayon

G. Remove the valve core to release air pressure

H. Remove the tire beads from the rim bead seat (Figure 2)

(NOTE: If a tire machine is used, follow manufacturer's procedures.)

FIGURE 2



I. Apply rubber lubricant to the tire bead

(CAUTION: Lubricate only with approved lubricant or a thin vegetable oil and soap solution. Never use antifreeze, silicones, or petroleum-based lubricants.)

JOB SHEET #1

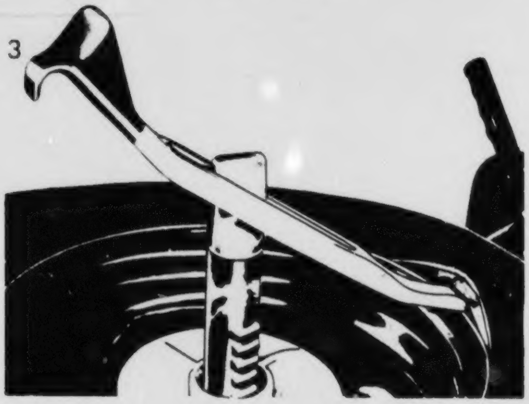
J. Remove the tire bead from the narrow side of the rim

- a. Work the other bead into the center wheel well
- b. Start prying the bead off opposite the valve stem on tube tires

  (NOTE: As the bead is being pried over the rim, guide the back side of the bead into the wheel center well. See Figure 3.)

  (CAUTION: Use care to avoid pinching the inner tube with the tire irons.)

FIGURE 3

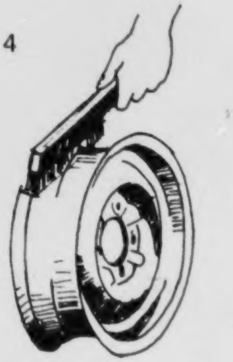


K. Remove the inner tube if so equipped

L. Remove the tire from the wheel by prying the lower bead over the narrow side of the rim

M. Clean rim flanges and bead seat areas with a wire brush to remove oxidized rubber, dried soap solution, rust, and other inappropriate materials (Figure 4)

FIGURE 4

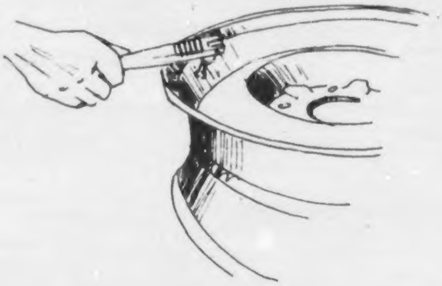


(CAUTION: Never reuse a wheel that has been damaged, welded, or brazed.)

JOB SHEET #1

N. Inspect valve stem and replace if damaged or deteriorated (Figure 5)

FIGURE 5



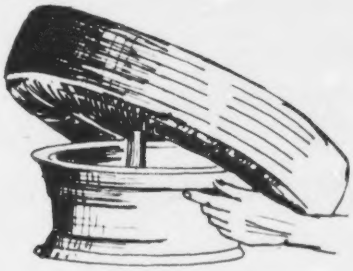
O. Repair or replace tire as necessary

P. Replace the tire on the wheel

1. Place the wheel down with the narrow bead area up
2. Lubricate tire beads and rim bead areas
3. Push the bottom bead in the well of the wheel (Figure 6)

   (CAUTION: Be sure there are no tools, foreign objects, or liquids inside the tire casing.)

FIGURE 6

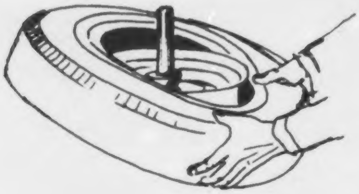


4. Work the tire bead on with tire irons
5. Install the inner tube if so equipped

JOB SHEET #1

6. Push the top bead into the well of the wheel while working the remainder of the bead onto the rim (Figure 7)

FIGURE 7

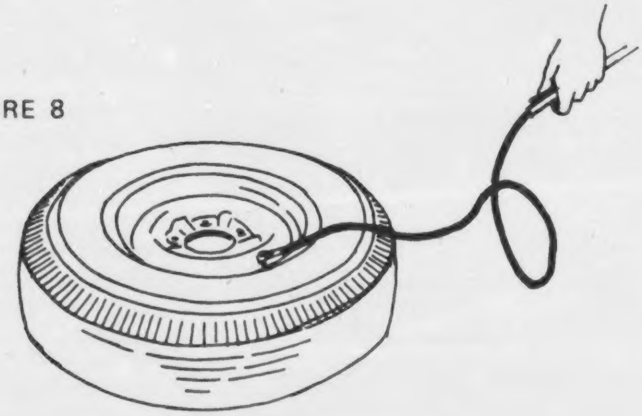


Q. Inflate the tire to a maximum pressure of 40 psi to seat the beads

(NOTE: The valve core should be in place. If the beads do not seat at this pressure, break the beads loose and relubricate the wheel and beads. Align the tire more accurately while inflating the tire.)

(CAUTION: Use an extension hose with gauge and clip-on chuck so that you can stand clear of tire assembly. See Figure 8.)

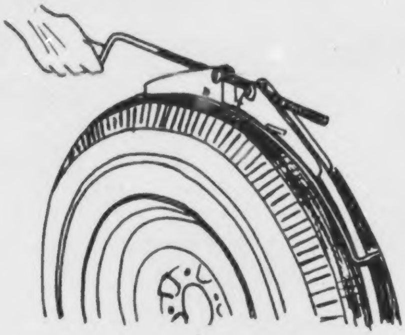
FIGURE 8



JOB SHEET #1

R. Spread the beads of the tubeless tire against the rim with a tool similar to that in Figure 9

FIGURE 9



S. Adjust air pressure to vehicle manufacturer's specifications

T. Immerse the tire and wheel assembly in the leak test tank to check for leaks

TIRES AND WHEELS
UNIT II

JOB SHEET #2--REPAIR A TIRE PUNCTURE

I. Tools and materials

   A. Tire marking crayon

   B. Chemical buffer solution

   C. Vulcanizing cement

   D. Buffing tool (manual or power)

   E. Awl

   F. Stitching tool

   G. Tire spreader

   H. Pliers

   I. Cold patches

   J. Hot patch clamp

   K. Hot patches

   L. Assortment of plugs

   M. Matches

   N. Soap solution

II. Procedure

   A. Clean the tire and wheel

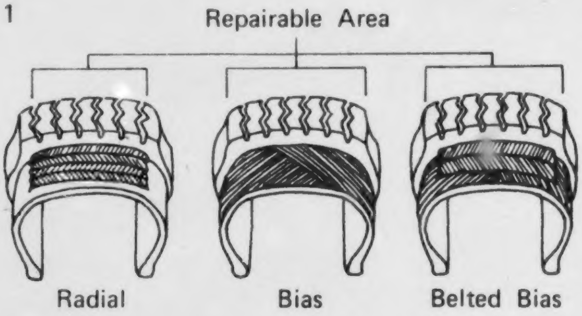
   B. Remove the nail or other puncture object from the tire

JOB SHEET #2

C. Apply soap solution to the damaged area of the inflated tire to determine if air loss is from one or more punctures

(CAUTION: Never repair tires if the tread is worn below 1/16", if the tread puncture is larger than 1/4", or if the puncture is inside the wall. See Figure 1. Tires having injuries beyond these limitations should be repaired by specially trained personnel and special equipment.)

FIGURE 1

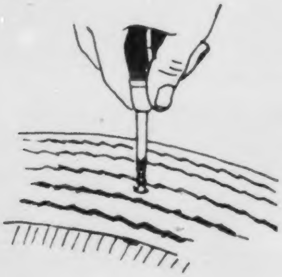


D. Deflate the tire

E. Remove the tire from the wheel

F. Probe the puncture with an awl to determine size and direction of injury (Figure 2)

FIGURE 2

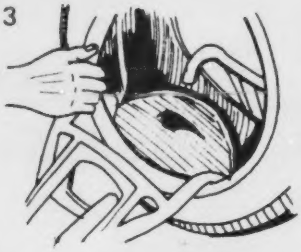


G. Remove any contamination from the injury

JOB SHEET #2

H. Mount the tire in the spreader so that the injury is bulged inside the tire (Figure 3)

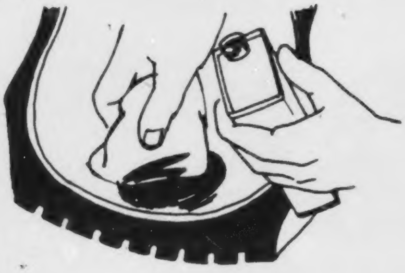
FIGURE 3



I. Inspect the puncture for evidence of other damage

J. Clean the puncture area thoroughly with chemical buffer, covering a slightly larger area than required for the patch (Figure 4)

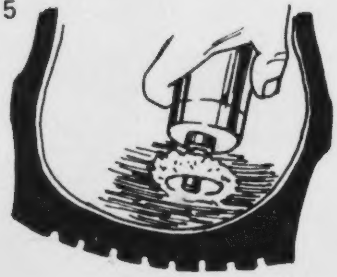
FIGURE 4



K. Buff the cleaned area thoroughly (Figure 5)

(CAUTION: Do not cut through the liner with the buffer.)

FIGURE 5



JOB SHEET #2

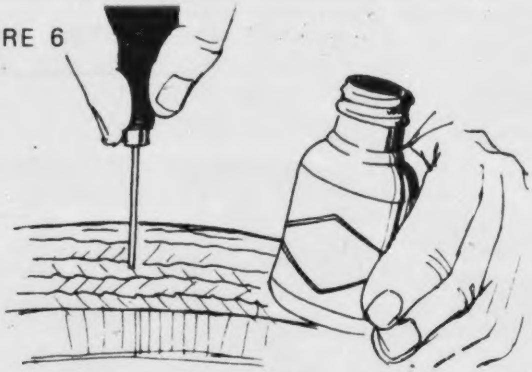
L. Remove dust and any other particles from inside the tire

M. Finish repair by selecting one of the following methods

1. Repair with cold patch, plug, or patch-plug combination

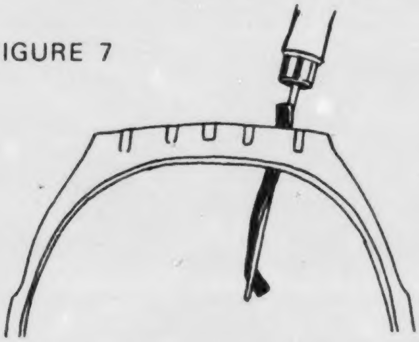
   a. Swab the puncture with chemical vulcanizing cement (Figure 6)

FIGURE 6



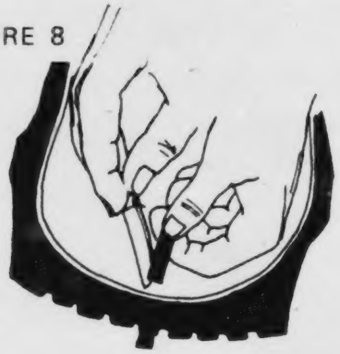
   b. Fill the puncture with a headless rubber plug (Figure 7)

FIGURE 7



   c. Trim the plug flush with the tire, inside and outside (Figure 8)

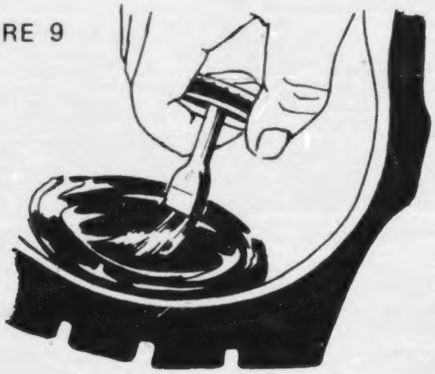
FIGURE 8



JOB SHEET #2

d. Apply chemical vulcanizing cement on the buffed area inside the tire and allow to dry thoroughly (Figure 9)

FIGURE 9

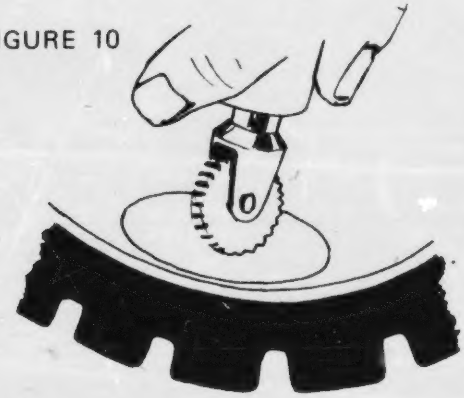


e. Remove the backing from the patch

f. Center the patch over the puncture

g. Stitch the patch down with the stitching tool by working outward from the center (Figure 10)

FIGURE 10

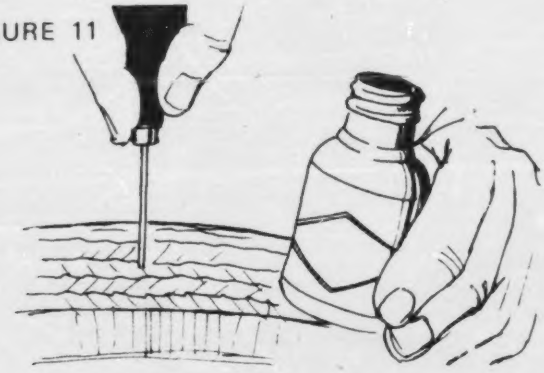


JOB SHEET #2

2. Repair puncture with the hot patch method

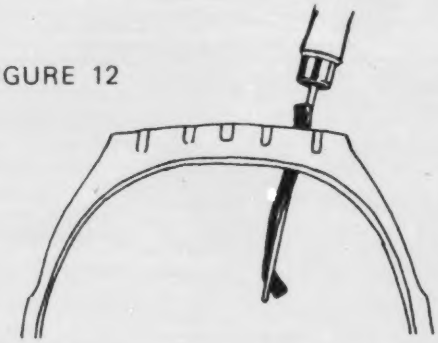
   a. Swab the puncture with chemical vulcanizing cement (Figure 11)

FIGURE 11



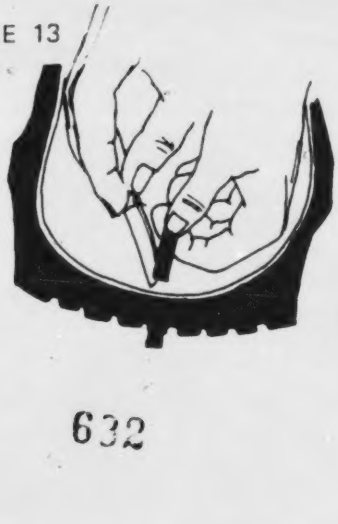
   b. Fill the puncture with a headless rubber plug (Figure 12)

FIGURE 12



   c. Trim the plug flush with the tire inside and outside (Figure 13)

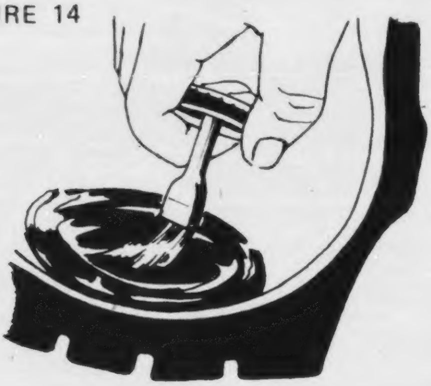
FIGURE 13



JOB SHEET #2

d. Apply the appropriate chemical vulcanizing cement on the buffed area and allow to dry thoroughly (Figure 14)

FIGURE 14



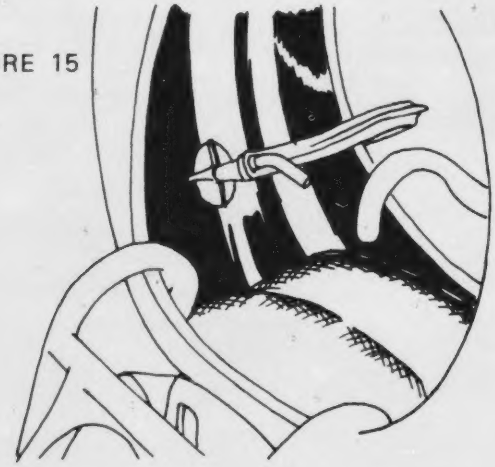
e. Remove the protective backing on the hot patch

f. Center the hot patch over the puncture

g. Apply pressure to the hot patch with the special clamp

h. Cure the patch according to manufacturer's recommendations (Figure 15)

FIGURE 15



JOB SHEET #2

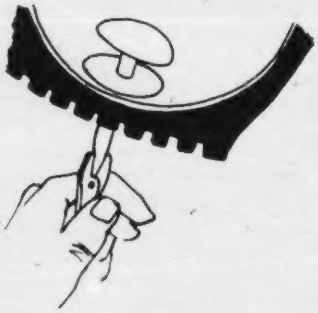
3. Repair puncture with head type plug method

    a. Apply a thin coat of chemical vulcanizing cement inside the puncture and around the punctured area; allow to dry thoroughly

    b. Remove the protective backing from the plug stem and head

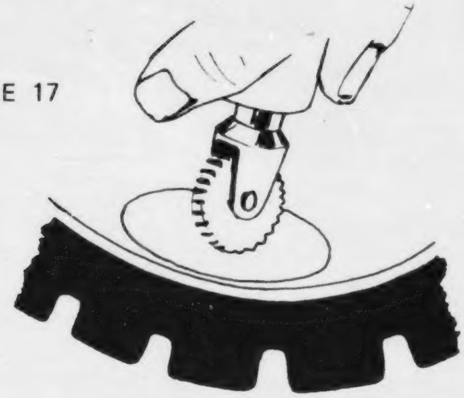
    c. Pull the plug stem through the tire from the inside until the head seats on the inner liner (Figure 16)

FIGURE 16



    d. Stitch the head down by working outward from the center (Figure 17)

FIGURE 17



(NOTE: Regardless of the type of repair used, finished repairs should seal the inner liner and fill the puncture. After inflating the tire, check finished repair with water or soap solution to insure a complete seal.)

TIRES AND WHEELS
UNIT II

TEST

1. Match the terms on the right to the correct definitions. (Answers for "a" through "k" are on this page.)

_____a. Body ply that is laid at a 90° angle from bead to bead

_____b. Body ply that is laid on a bias (30° - 60° angle) from bead to bead with the cord angle reversed on alternating plies

_____c. That portion of the tire that bears against the rim flange and consists of a number of turns of steel wire to provide greater strength

_____d. Area of the tire that contacts the road

_____e. Main body of the tire exclusive of the tread

_____f. Rubber tube mounted in the rim or attached to the inner tube to provide a way to inflate or deflate the tire

_____g. Diameter of the wheel from tire bead seat to tire bead seat

_____h. One-half inch (12.7 mm) wide bands across the tread that appears when tread depth is reduced to 1/16 inch (1.587 mm)

_____i. How true the tire or wheel rotates with respect to lateral movement and radial movement

_____j. Layer of cord impregnated with rubber and shaped to form the body of the tire

_____k. Prefix letter of the tire size markings located on the tire sidewall; refers to the vehicle body size (compact, intermediate, and full-size) that the tire is designed to fit

1. Tire tread
2. Tire bead
3. Tire casing
4. Tire ply
5. Bias ply
6. Radial ply
7. Rim diameter
8. Tire size range
9. Valve stem
10. Tire tread wear indicator
11. Tire and wheel runout

(Answers to "l" through "t" are on this page.)

______ l. Ratio of tire height to tire width

______ m. Check valve installed in the valve stem that allows air to enter the tire or tube but prevents air from escaping

______ n. Tire that seals to the rim with sealing grooves on the tire bead area and seals the casing with a soft rubber inner surface, eliminating the need for an inner tube

______ o. System that replaces the ply system for indicating weight-carrying capacity of a tire

______ p. Air-tight rubber tube placed inside the casing of a pneumatic tire to hold air under pressure

______ q. Ply applied directly beneath the tire tread and parallel to the tread

______ r. Rim that has a broad groove or "dropped" area in its center to allow the removal of the tire

______ s. Bulge on a tire where air has penetrated through the body plies and separated the sidewall or tread from the outer ply

______ t. Process of heating rubber under pressure to give shape and desired characteristics to the tire

12. Drop center wheel
13. Vulcanizing
14. Tire load range
15. Aspect ratio
16. Stabilizer belt
17. Tire separation
18. Valve core
19. Inner tube
20. Tubeless tire

2. State the two basic functions of tires.

   a.

   b.

3. Name the two basic types of tires.

   a.

   b.

4. Identify the parts of the tire in the drawing below by placing the correct numbers in the blanks provided.

_____a. Bead wires

_____b. Rubber chafer

_____c. Wall rubber

_____d. Fillers

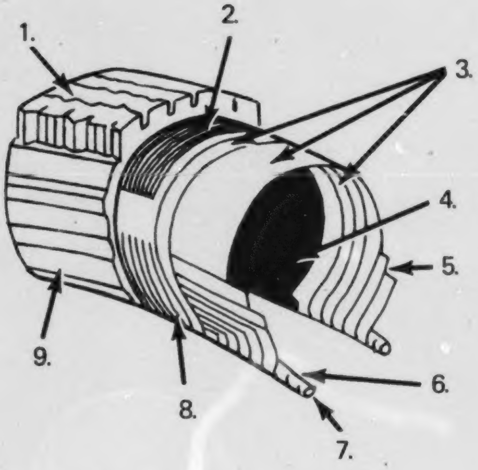
_____e. Tread

_____f. Casing plies

_____g. Inner liner

_____h. Bead wrapping

_____i. Undertread



5. Describe the way in which each of the following tire plies is laid.

a. Radial ply

b. Bias ply

c. Belted ply

6. Complete the chart below.

Cord Type	Tensile Strength, PSI	Advantages
a.	122,000 psi (8577.57 kg/cm^2)	High heat resistance, excellent impact resistance, minimum flex, water repellent
b.	94,000 psi (6608.95 kg/cm^2)	Soft ride, resilient, inexpensive
c.	407,000 psi (28,615.35 kg/cm^2)	Greatest strength, soft ride
d.	104,000 psi (7322.03 kg/cm^2)	Soft ride, more heat resistant, inexpensive

7. Identify the abnormal tire tread wear patterns below by placing the correct numbers in the blanks provided.

______a. Toe-in wear

______b. Cornering wear

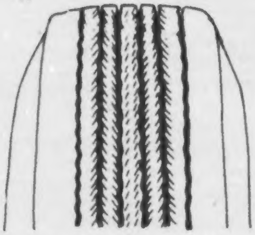
______c. Underinflation wear

______d. Camber wear

______e. Overinflation wear

______f. Multi-problem wear

1.



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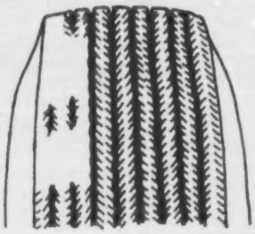
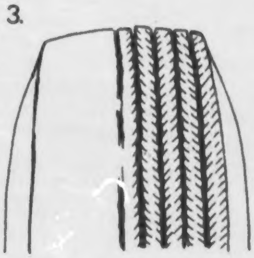
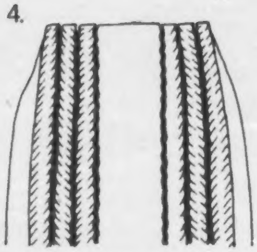


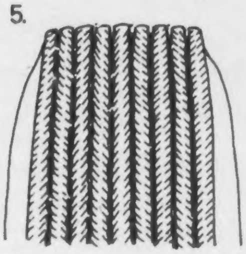
3.



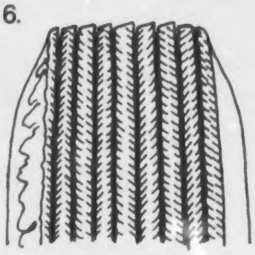
4.



5.



6.



8. Identify the tire size markings in the drawings below by placing the correct numbers in the blanks provided.

Late

______a. Aspect ratio

______b. Size range

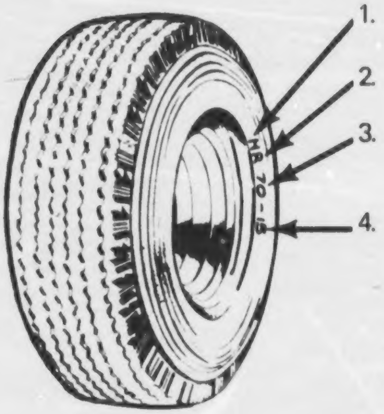
______c. Rim diameter in inches

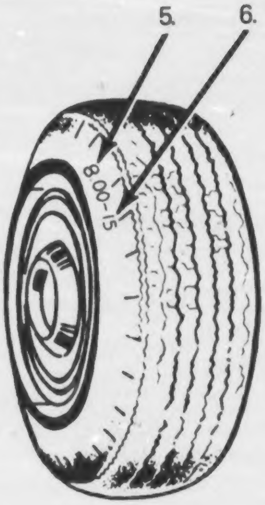
______d. Radial ply

Early

______e. Rim diameter in inches

______f. Tire height in inches





9. Complete the following chart by writing the correct load range in the spaces provided.

Load Range	Tire Ply Rating
a.	4 ply with 8 ply rating; 8 ply
b.	6 ply
c.	2 ply with 4 ply rating; 4 ply

10. Discuss tire inflation pressure.

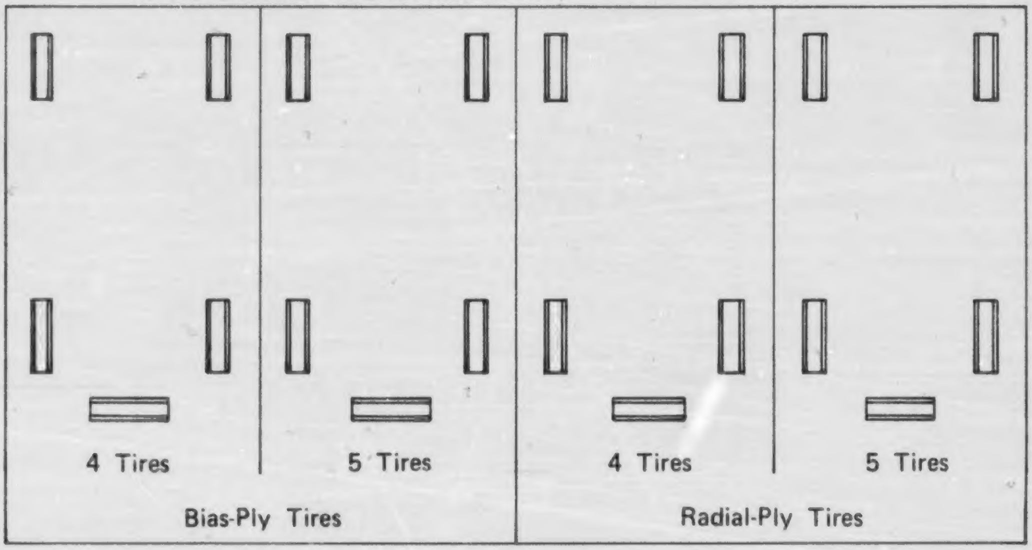
11. List three reasons for periodic tire rotation.

    a.

    b.

    c.

12. Draw tire rotation patterns for the followings types of tires by placing arrows in the direction of tire movement.


4 Tires
5 Tires
4 Tires
5 Tires
Bias-Ply Tires
Radial-Ply Tires

13. List three methods of repairing minor tire punctures.

    a.

    b.

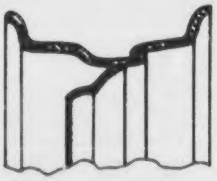
    c.

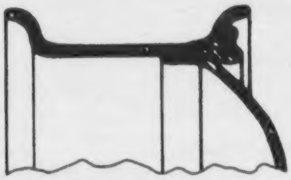
14. Identify the following types of wheels by placing the correct numbers in the blanks provided.

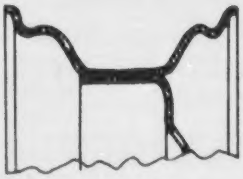
______a. Drop center

______b. Two piece split rim

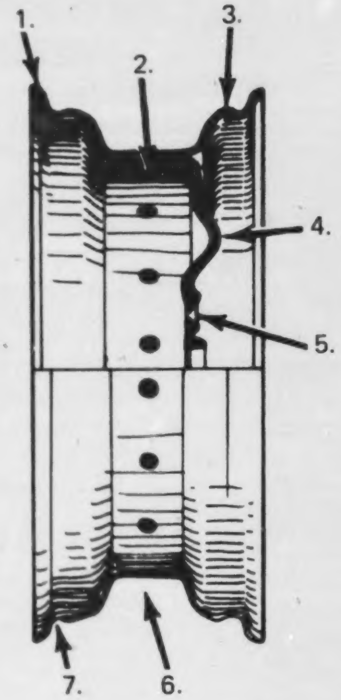
______c. Three piece split rim

1.


2.


3.


15. Identify the parts of the drop center wheel in the drawing below by placing the correct numbers in the blanks provided.



______a. Center section

______b. Flange

______c. Tire bead seat area

______d. Drop center area

______e. Safety ridge

______f. Mounting hole

______g. Rivet

16. Demonstrate the ability to:

a. Remove, inspect, and replace a tire on a wheel.

b. Repair a tire puncture.

(NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

TIRES AND WHEELS
UNIT II

ANSWERS TO TEST

1.
   - a. 6
   - b. 5
   - c. 2
   - d. 1
   - e. 3
   - f. 9
   - g. 7
   - h. 10
   - i. 11
   - j. 4
   - k. 8
   - l. 15
   - m. 18
   - n. 20
   - o. 14
   - p. 19
   - q. 16
   - r. 12
   - s. 17
   - t. 13
2.
   - a. Absorb the shock of irregular road surfaces
   - b. Provide good traction between the road and the wheel
3.
   - a. Tube
   - b. Tubeless
4.
   - a. 7
   - b. 8
   - c. 9
   - d. 5
   - e. 1
   - f. 3
   - g. 4
   - h. 6
   - i. 2
5.
   - a. Radial ply--The casing plies are laid at right angles to the circumference of the tire
   - b. Bias ply--The casing plies are laid on the bias or crisscross at an angle of 30° to 38°
   - c. Belted ply--Additional plies are added directly under the tire tread
6.
   - a. Nylon
   - b. Rayon

c. Fiberglass

d. Polyester

7. a. 5 d. 3

b. 6 e. 4

c. 1 f. 2

8. a. 3 d. 2

b. 1 e. 6

c. 4 f. 5

9. a. D

b. C

c. B

10. a. Tire pressure should be checked when cold

b. Tire pressure should be the same as the vehicle manufacturer's specifications

c. Tire pressure may vary from vehicle specifications only to correct tire wear due to inflation pressures

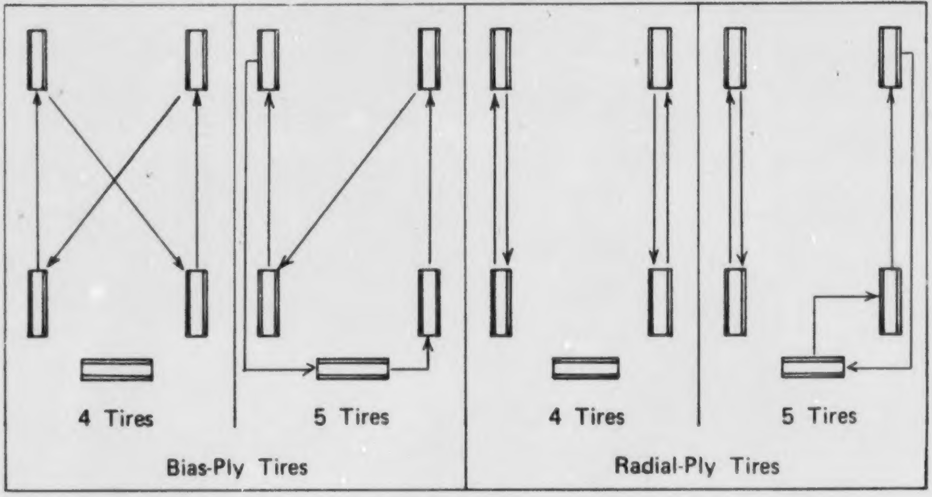
d. Tire pressure should be checked each month or sooner if inspection indicates a low condition

11. a. Equalizes tire wear

b. Minimizes the possibility of tire noise

c. Allows for close tire inspection

12.


4 Tires
5 Tires
4 Tires
5 Tires
Bias-Ply Tires
Radial-Ply Tires

13. a. Hot patch
    b. Cold patch
    c. Rubber plug

14. a. 3
    b. 1
    c. 2

15. a. 4
    b. 1
    c. 7
    d. 6
    e. 3
    f. 5
    g. 2

16. Performance skills evaluated to the satisfaction of the instructor

WHEEL BALANCING
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the types of wheel balancers and state reasons for balancing wheels. The student should be able to check tire and wheel runout and balance a tire and wheel assembly. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with wheel balancing to the correct definitions.
2. List advantages of balancing wheels.
3. Discuss the types of wheel balance.
4. State the conditions which would require rebalancing of the wheels.
5. Identify the types of wheel balancers.
6. Discuss the types of wheel weights and their uses.
7. Demonstrate the ability to:
    a. Check tire and wheel runout.
    b. Static balance a tire and wheel assembly.
    c. Spin balance a tire and wheel assembly on the car.

WHEEL BALANCING
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Collect tools and equipment necessary for demonstrating job sheets.

   E. Discuss unit and specific objectives.

   F. Discuss information sheet.

   G. Demonstrate and discuss procedures outlined in the job sheets.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Demonstrate the ability to accomplish the procedures outlined in the job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Tire Tramp and Wheel Shimmy

      2. TM 2--Static and Dynamic Balance

        3. TM 3--Types of Wheel Balancers

        4. TM 4--Types of Wheel Weights

    D. Job sheets

        1. Job Sheet #1--Check Tire and Wheel Runout

        2. Job Sheet #2--Static Balance a Tire and Wheel Assembly

        3. Job Sheet #3--Spin Balance a Tire and Wheel Assembly on the Car

    E. Test

    F. Answers to test

II. References:

A. Bacon, E. Miles. *Principles of Wheel Alinement Service.* New York: McGraw-Hill Book Co., 1971.

B. Stockel, Martin W. *Auto Mechanics Fundamentals.* South Holland, Illinois: Goodheart-Willcox Co., 1969.

WHEEL BALANCING
UNIT III

INFORMATION SHEET

I. Terms and definitions

  A. Wheel balancing--Placement of wheel weights around the wheel rim to counteract the centrifugal forces acting upon heavy areas of the tire and wheel assembly that would keep the tire from rolling smooth

  B. Wheel weight--Lead bar attached to the wheel as a counter balance (Transparency 4)

  (NOTE: Wheel weights vary in size from 1/4 - 6 oz.)

  C. Tire tramp--Hopping motion of the tire and wheel assembly due to an out-of-balance condition (Transparency 1)

  D. Wheel shimmy--Violent back-and-forth shaking of the steering wheel caused by rapid side-to-side whipping of the front tires (Transparency 1)

  E. Tire and wheel runout--Amount of trueness that the tire or wheel rotates with respect to lateral movement (wobble) and radial movement (difference between high and low points of tread or rim flange)

II. Advantages of balancing wheels

  A. Provides greater vehicle stability by keeping the tires on the pavement

  B. Reduces tire wear

  C. Reduces excessive suspension wear

  D. Provides a smoother ride

  E. Eliminates wheel shimmy

III. Types of balance

  A. Static balance--Balancing a tire at rest by adding a compensating weight to offset a heavy area of the tire (Transparency 2)

  B. Dynamic balance--Balancing a wheel in motion so that the center line of the weight of the revolving tire is in the same plane as the center line of the tire (Transparency 2)

INFORMATION SHEET

IV. Conditions which require rebalancing of the wheel

- A. Loss of a wheel weight
- B. Mounting of new tires
- C. Rotation of tires

  (NOTE: This depends on the type of balancer used at the time of initial balance.)
- D. Flat tire
- E. Abnormal tire wear that causes a change in the tire
- F. Every 10,000 miles

  (NOTE: Tires should be rebalanced under normal conditions once a year or approximately every 10,000 miles.)

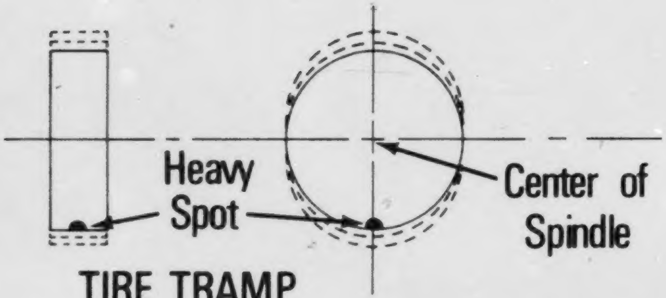
V. Types of wheel balancers (Transparency 3)

- A. Static
- B. On-the-car spin
- C. Off-the-car spin

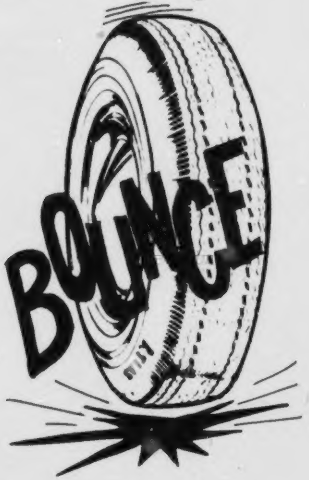
VI. Types of wheel weights and their uses (Transparency 4)

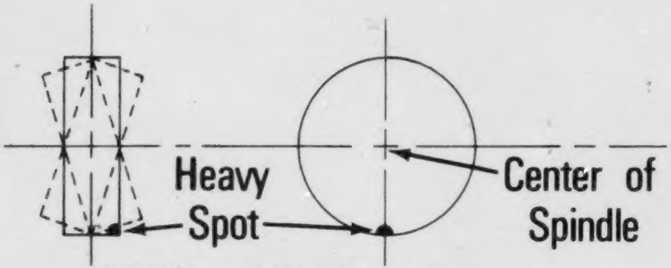
- A. Clip-on--Wheel weight with a spring steel attaching clip used on standard steel wheels
- B. Tape-on--Wheel weight with an attaching adhesive on the back to use on chrome, magnesium, and aluminum wheels

Tire Tramp and Wheel Shimmy

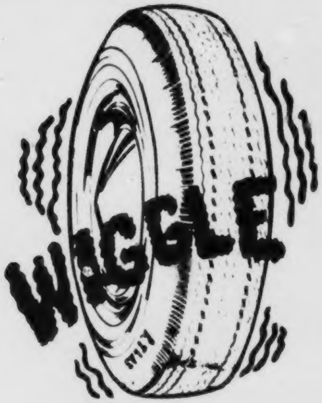

Heavy Spot
Center of Spindle

TIRE TRAMP

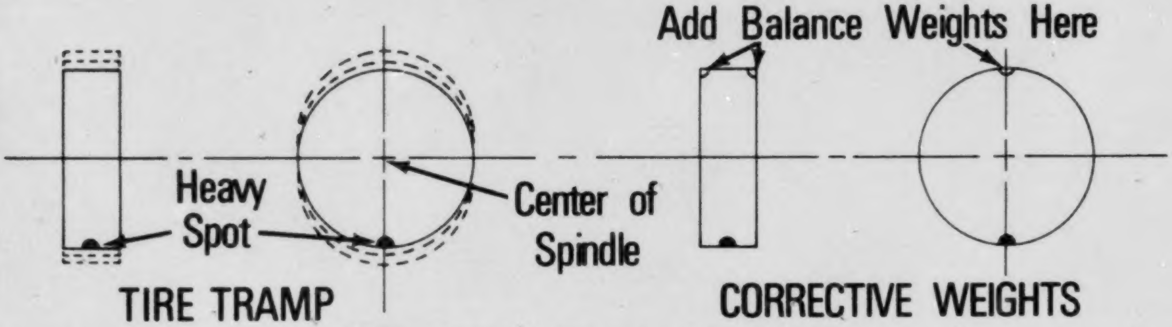



Heavy Spot
Center of Spindle

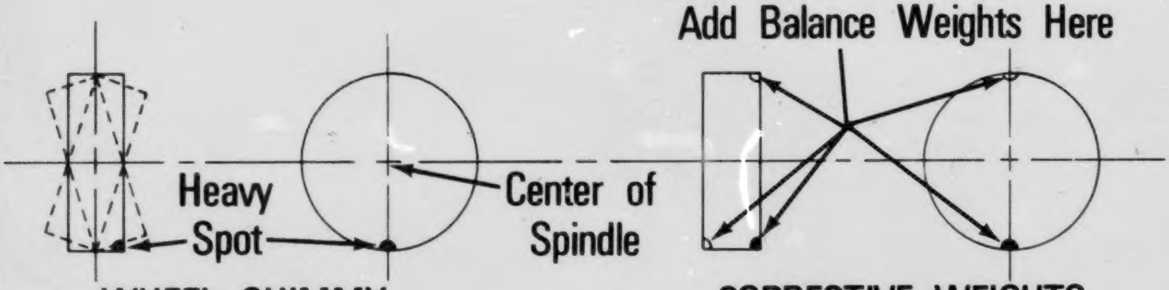
WHEEL SHIMMY



Static and Dynamic Balance

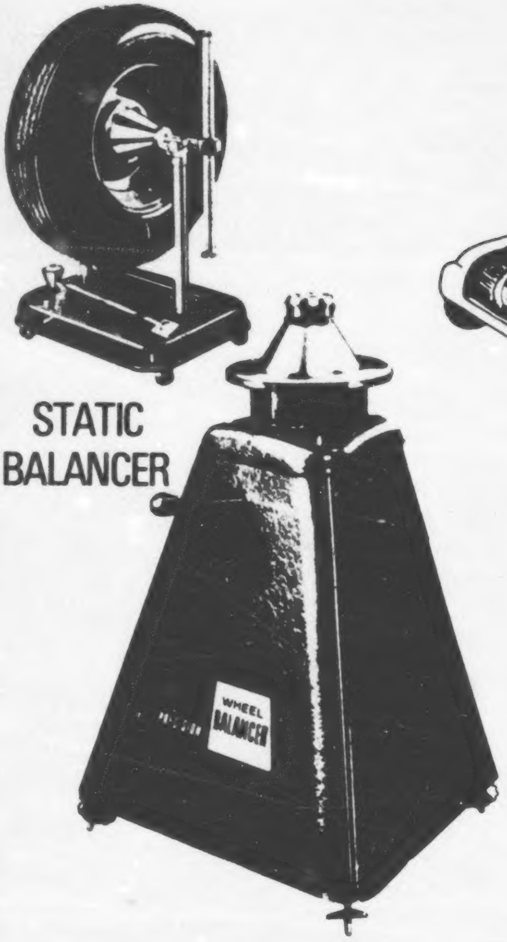

Add Balance Weights Here
Heavy Spot
Center of Spindle
TIRE TRAMP
CORRECTIVE WEIGHTS

STATIC BALANCE

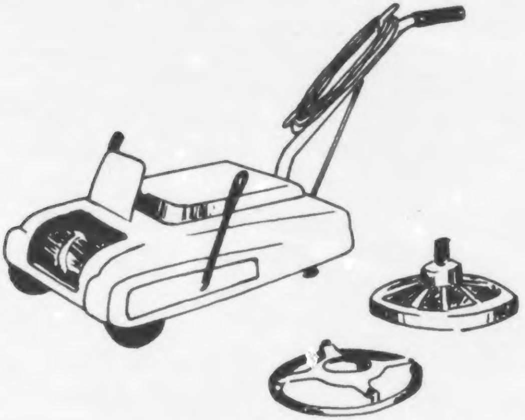

Add Balance Weights Here
Heavy Spot
Center of Spindle
WHEEL SHIMMY
CORRECTIVE WEIGHTS

DYNAMIC BALANCE

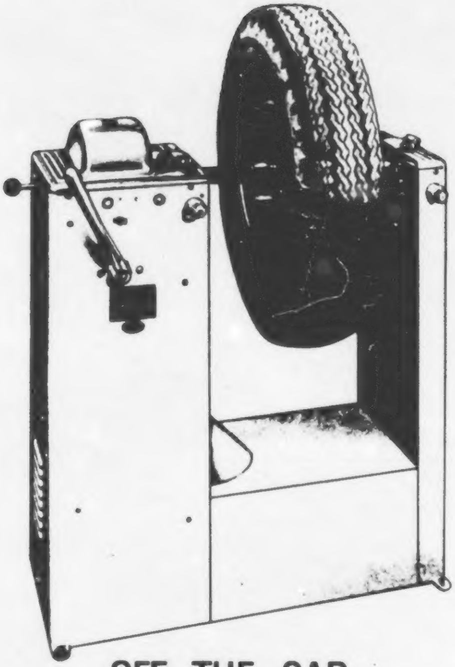
Types of Wheel Balancers


WHEEL
BALANCER

STATIC
BALANCER



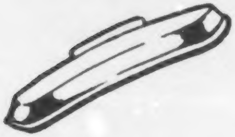
ON–THE–CAR
SPIN BALANCER



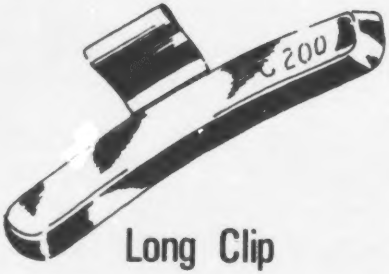
OFF–THE–CAR
SPIN BALANCER

Types of Wheel Weights

Clip-on

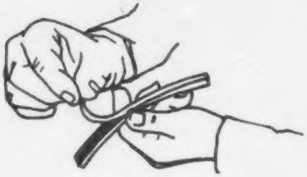


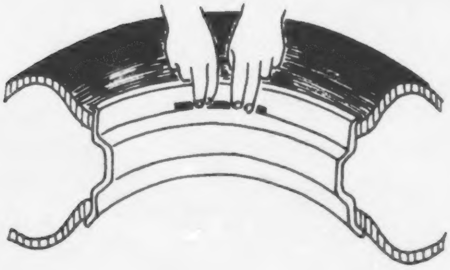
Short Clip



Long Clip

Tape-on





WHEEL BALANCING
UNIT III

JOB SHEET #1--CHECK TIRE AND WHEEL RUNOUT

I. Tools and equipment

   A. Floor jack

   B. Jack stands

   C. Runout gauge

      (NOTE: A dial indicator may be substituted.)

   D. Chalk

II. Procedure

   A. Check tire inflation pressure

   B. Check lug bolt torque

   C. Drive the vehicle several miles to heat the tires

   D. Raise the vehicle

   E. Support on jack stands

      (NOTE: This should be done as soon as possible after driving the vehicle to avoid a false reading due to the tendency of tires to take a temporary "set" after standing for a period of time.)

   F. Adjust wheel bearings

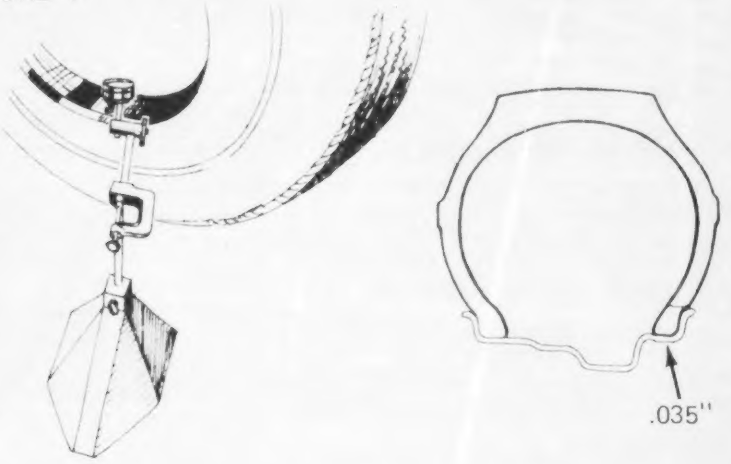
   G. Clean dirt and gravel from the wheel and tire assembly

   H. Check wheel radial runout with runout gauge

      (NOTE: See Figure 1 on the following page.)

JOB SHEET #1

FIGURE 1

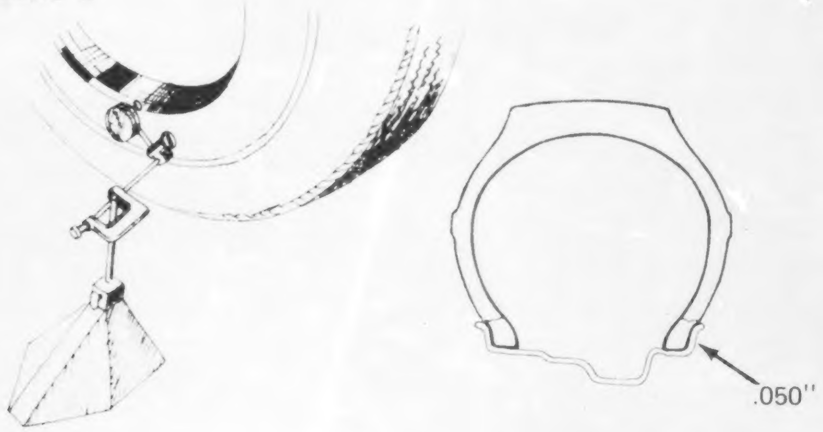


I. Rotate the wheel slowly by hand; observe gauge reading through one complete turn

J. Mark the wheel with chalk at any point the gauge reading exceeds 0.035"

K. Check wheel lateral runout with the gauge (Figure 2)

FIGURE 2



L. Rotate the wheel slowly by hand; observe gauge reading through one complete turn

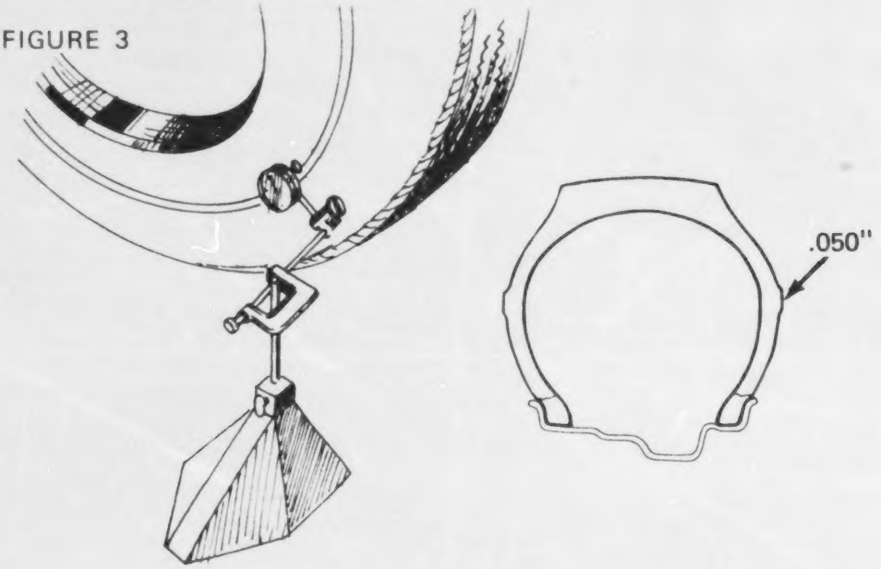
M. Mark the wheel with chalk at any point the gauge reading exceeds 0.050"

(NOTE: The maximum allowable lateral wheel runout is 0.050".)

JOB SHEET #1

N. Check tire lateral runout with gauge (Figure 3)

FIGURE 3



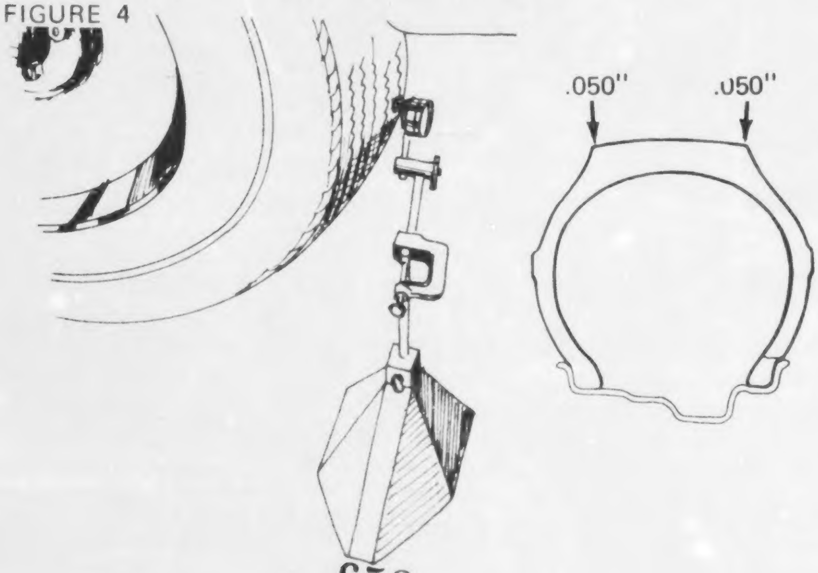
O. Rotate the tire slowly by hand; observe gauge reading through one complete turn

P. Mark the tire with chalk at any point the gauge reading exceeds 0.050"

(NOTE: The maximum allowable lateral runout of the tire is 0.050".)

Q. Check tire radial runout with the gauge (Figure 4)

FIGURE 4



JOB SHEET #1

R. Rotate the tire slowly by hand; observe the gauge reading through one complete turn

S. Mark the tire with chalk at any point the gauge reading exceeds 0.050"

(NOTE: The maximum allowable radial tire runout is 0.050".)

T. Repair or replace the tire or wheel

1. Replace the wheel if there were any chalk marks on either lateral or radial runout areas

   (NOTE: Rims that are not bent severely may be straightened if a special machine is available.)

2. Replace the tire only after it has been determined that the wheel is true and the tire is out of limits

   (NOTE: Some manufacturers recommend rotating the tire 180° on the rim and rechecking runout before replacing the tire.)

WHEEL BALANCING
UNIT III

JOB SHEET #2--STATIC BALANCE A TIRE AND WHEEL ASSEMBLY

I. Tools and equipment

- A. Floor jack
- B. Jack stands
- C. Large screwdriver
- D. Lug wrench
- E. Ice pick
- F. Wheel weight pliers
- G. Static wheel balancer
- H. Wheel weights, assorted sizes 1/2 - 6 oz

II. Procedure

- A. Raise the vehicle with the floor jack
- B. Support the vehicle on jack stands
- C. Remove the wheel cover on the tire to be balanced

  (NOTE: Check wheel runout if the problem so indicates.)
- D. Remove the tire and wheel assembly
- E. Clean the tread grooves of the tire
- F. Clean the wheel
- G. Remove all wheel weights
- H. Balance the tire and wheel assembly according to balancer manufacturer's procedures
- I. Divide the weight in half when the weight is two ounces or more and place half on each side of the wheel in the correct position
- J. Replace the tire and wheel assembly on the vehicle

JOB SHEET #2

K. Torque the lug nuts

L. Replace the wheel cover

M. Lower the vehicle to the floor

N. Road test the vehicle with the instructor

WHEEL BALANCING
UNIT III

JOB SHEET #3--SPIN BALANCE A TIRE AND WHEEL ASSEMBLY ON THE CAR

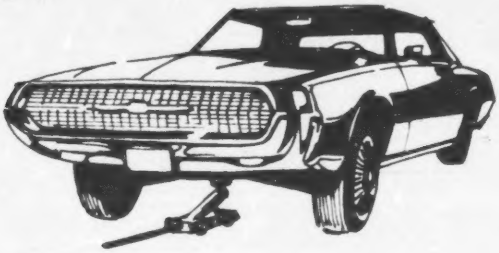
I. Tools and equipment

- A. Floor jack
- B. Jack stands
- C. Large screwdriver
- D. Lug wrench
- E. Ice pick
- F. Wheel weight pliers
- G. Spin type wheel balancer
- H. Wheel weights, assorted sizes 1/2 - 6 oz

II. Procedure

- A. Raise the vehicle with the floor jack on the center of the frame front crossmember (Figure 1)

FIGURE 1



- B. Support the vehicle so that the tires are approximately 3" off the floor
- C. Remove the wheel cover

JOB SHEET #3

D. Check tire inflation pressure

E. Check wheel bearing adjustment

F. Clean tire tread of large particles of gravel or dirt

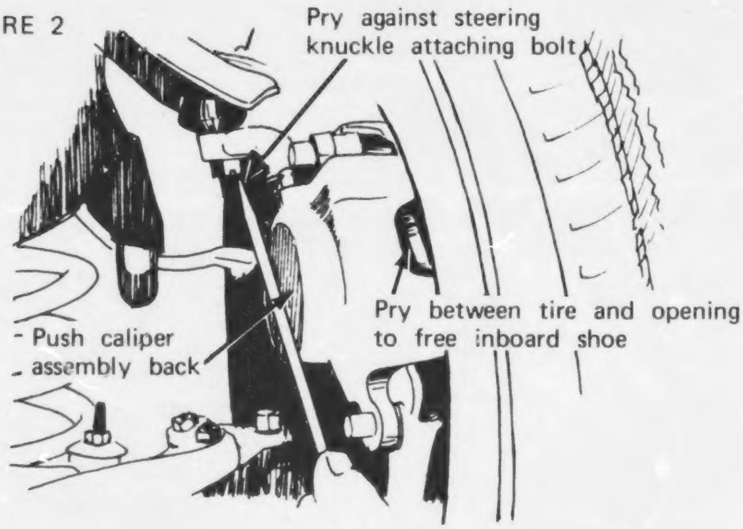
G. Clean dirt and other material from both sides of the wheel

(NOTE: Remove the wheel assembly if necessary.)

H. Balance the tire and wheel assembly according to the balancer manufacturer's procedures

(NOTE: On disc brake models it may be necessary to release caliper pressure. See Figure 2.)

FIGURE 2


Pry against steering knuckle attaching bolt
Pry between tire and opening to free inboard shoe
Push caliper assembly back

I. Replace the wheel cover

J. Lower the vehicle to the floor

K. Road test with the instructor

WHEEL BALANCING
UNIT III

TEST

1. Match the terms on the right to the correct definitions.

    _____a. Placement of wheel weights around the wheel rim to counteract the centrifugal forces acting upon heavy areas of the tire and wheel assembly that would keep the tire from rolling smooth

    _____b. Lead bar attached to the wheel as a counter balance

    _____c. Hopping motion of the tire and wheel assembly due to an out-of-balance condition

    _____d. Violent back-and-forth shaking of the steering wheel caused by rapid side-to-side whipping of the front tires

    _____e. Amount of trueness that the tire or wheel rotates with respect to lateral movement (wobble) and radial movement (difference between high and low points of tread or rim flange)

    1. Tire and wheel runout
    2. Wheel weight
    3. Tire tramp
    4. Wheel shimmy
    5. Wheel balancing

2. List five advantages of balancing wheels.

    a.

    b.

    c.

    d.

    e.

3. Discuss the types of wheel balance.

    a. Static balance

b. Dynamic balance

4. State six conditions which would require rebalancing of the wheel.

   a.

   b.

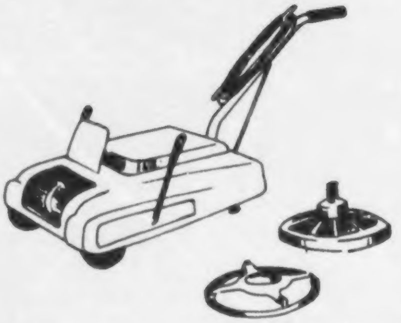
   c.

   d.

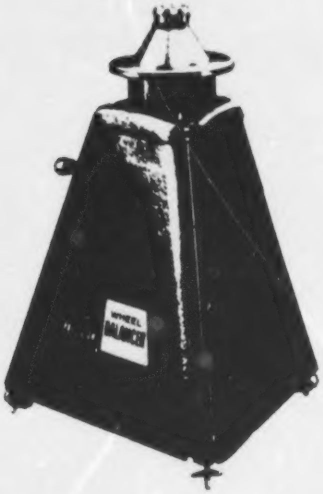
   e.

   f.

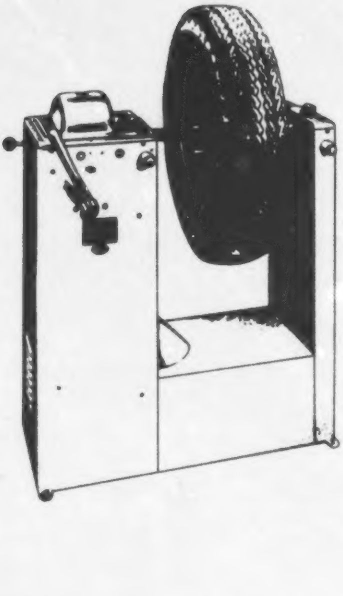
5. Identify the types of balancers in the drawings below by writing the correct names in the blanks provided.



b.____________________________



a.____________________________



c.____________________________

6. Discuss the types of wheel weights and their uses.

   a. Clip-on

   b. Tape-on

7. Demonstrate the ability to:

   a. Check tire and wheel runout.

   b. Static balance a tire and wheel assembly.

   c. Spin balance a tire and wheel assembly on the car.

   (NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

WHEEL BALANCING
UNIT III

ANSWERS TO TEST

1. a. 5

   b. 2

   c. 3

   d. 4

   e. 1

2. a. Provides greater vehicle stability by keeping the tires on the pavement

   b. Reduces tire wear

   c. Reduces excessive suspension wear

   d. Provides a smoother ride

   e. Eliminates wheel shimmy

3. Discussion should include:

   a. Static balance--Balancing a tire at rest by adding a compensating weight to offset a heavy area of the tire

   b. Dynamic balance--Balancing a wheel in motion so that the center line of the weight of the revolving tire is in the same plane as the center line of the tire

4. a. Loss of a wheel weight

   b. Mounting of new tires

   c. Rotation of tires

   d. Flat tire

   e. Abnormal tire wear that causes a change in the tire

   f. Every 10,000 miles

5. a. Static balancer

   b. On-the-car spin balancer

   c. Off-the-car spin balancer

6. Discussion should include:
   a. Clip-on--Wheel weight with a spring steel attaching clip used on standard steel wheels
   b. Tape-on--Wheel weight with an attaching adhesive on the back to use on chrome, magnesium, and aluminum wheels
7. Performance skills evaluated to the satisfaction of the instructor

SUSPENSION SYSTEM
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to state the purposes, define terms, and identify parts associated with the suspension system. The student should be able to inspect parts and make repairs on the suspension system. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. State the purposes of the suspension system.
2. Define terms associated with the suspension system.
3. Identify types of suspension systems.
4. Identify the parts of an independent front suspension.
5. Identify the parts of a coil spring solid axle rear suspension.
6. Discuss the types of suspension springs.
7. Identify the parts of a leaf spring.
8. Demonstrate the ability to:
    a. Inspect and replace shock absorbers.
    b. Inspect a front suspension for wear.
    c. Repair an upper control arm assembly on a lower control arm mounted coil spring.
    d. Repair a lower control arm assembly on a lower control arm mounted spring.

SUSPENSION SYSTEM
UNIT IV

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information sheet.
- F. Demonstrate and discuss procedures outlined in the job sheets.
- G. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Demonstrate the ability to accomplish the procedures outlined in the job sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
    1. TM 1--Solid Axle Leaf Spring Suspension
    2. TM 2--Solid Axle Coil Spring Suspension

3. TM 3--Independent Front Suspension
4. TM 4--Independent Rear Suspension with Swing Axle
5. TM 5--Semielliptical Leaf Spring
6. TM 6--Coil Spring
7. TM 7--Torsion Bar Spring
8. TM 8--Air Spring

D. Job sheets

1. Job Sheet #1--Inspect and Replace Shock Absorbers
2. Job Sheet #2--Inspect Front Suspension for Wear
3. Job Sheet #3--Repair an Upper Control Arm Assembly on a Lower Control Arm Mounted Coil Spring
4. Job Sheet #4--Repair a Lower Control Arm Assembly on a Lower Control Arm Mounted Spring

E. Test

F. Answers to test

II. References:

A. Stockel, Martin W. *Auto Mechanics Fundamentals*. South Holland, Illinois: Goodheart-Willcox Co., 1969.

B. Toboldt, William K., and Johnson, Larry. *Motor Service's Automotive Encyclopedia*. South Holland, Illinois: Goodheart-Willcox Co., 1970.

C. *Chevrolet Service Manual*. Detroit, Michigan: Chevrolet Motor Division, General Motors Corp., 1973.

D. *Plymouth Service Manual*. Detroit, Michigan: Chrysler-Plymouth Division, Chrysler Corp., 1967.

SUSPENSION SYSTEM
UNIT IV

INFORMATION SHEET

I. Purposes of the suspension system

   A. To allow the vehicle to travel over irregular surfaces with a minimum amount of up-down movement to the body

   B. To allow the vehicle to corner with minimum roll or tendency to break friction between tire and road

II. Terms and definitions

   A. Sprung weight--Weight of all vehicle parts supported by the springs

   B. Stabilizer bar--Transverse mounted spring steel bar that minimizes body lean or tipping while cornering

   C. Shock absorber--Hydraulic piston and cylinder device with one end attached to the frame and the other end attached to the axle to dampen or restrict the up-down movement of the springs

   D. S.L.A. type suspension (short-long arm)--Suspension system utilizing two control arms, with the upper arm shorter than the lower to allow the wheel to deflect up and down with a minimum change in camber

   (NOTE: *Camber* refers to the inward or outward tilt of the wheel at the top.)

III. Types of suspension systems

   A. Solid axle leaf spring (Transparency 1)

   B. Solid axle coil spring (Transparency 2)

   C. Independent front (Transparency 3)

      1. S.L.A. control arm arrangement

      2. Twin I-beam

   D. Independent rear with swing axle (Transparency 4)

IV. Parts of an independent front suspension--Lower control arm mounted coil spring (Transparency 3)

   A. Upper control arm (short arm)

   B. Coil spring

INFORMATION SHEET

C. Upper ball joint

D. Shock absorber

E. Upper control arm inner bushings

F. Lower control arm (long arm)

G. Lower ball joint

H. Lower control arm inner bushings and shaft

I. Steering knuckle

J. Stabilizer bar

K. Rubber bumper

V. Parts of a coil spring solid axle rear suspension (Transparency 2)

A. Lower control arm

B. Upper control arm

C. Shock absorber

D. Coil spring

VI. Types of suspension springs

A. Semielliptical leaf spring--A number of flat steel springs of varying lengths bolted together in the center to make a single unit and attached to the vehicle body at each end by shackles and to the axle by U-bolts (Transparency 5)

(NOTE: Some springs contain only the main leaf.)

B. Coil spring--Special steel spring rod wound into a spiral coil, with one end secured to the frame and the other to the axle or control arm (Transparency 6)

C. Torsion bar--Relatively long spring steel bar that has one end anchored to the frame and the other end to the lower control arm which twists the bar to allow the vehicle body to move up and down (Transparency 7)

D. Air spring--Cylinder and plunger separated by compressed air and placed between the axle and frame of the vehicle to provide a spring or cushion for the body of the vehicle (Transparency 8)

(NOTE: An air pump driven by the engine provides air pressure to fill the cylinder, which supports the vehicle. Vehicle height and level is maintained by a system of control valves.)

VII. Parts of a leaf spring (Transparency 5)

A. Main leaf

B. Leaf pad

C. Center bolt

D. Shackle assembly

E. Hanger assembly

F. Rebound clips

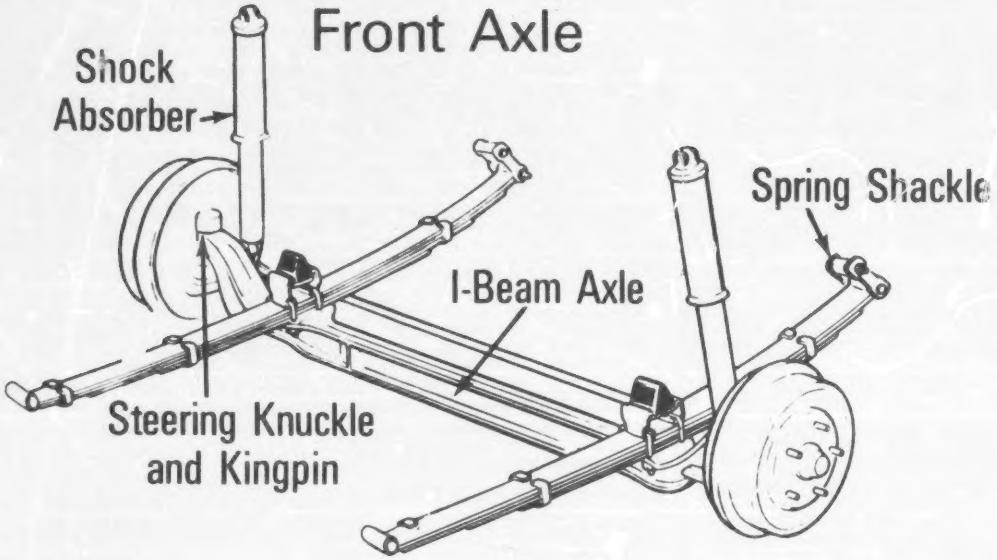
G. Bumpers

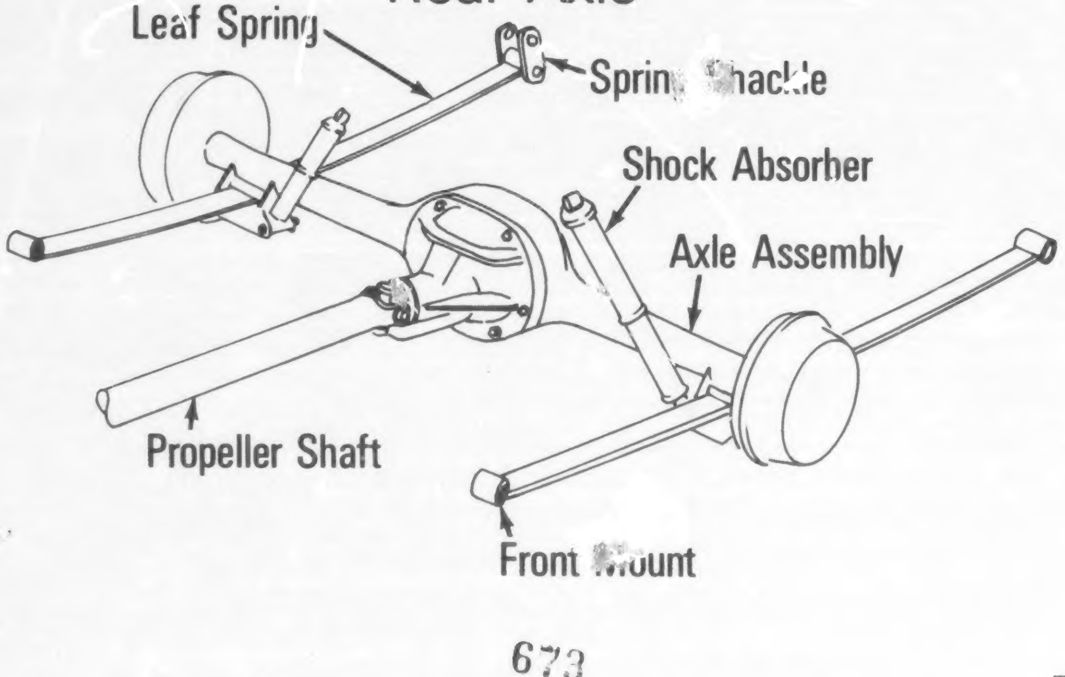
H. U-bolts

I. U-bolt plate

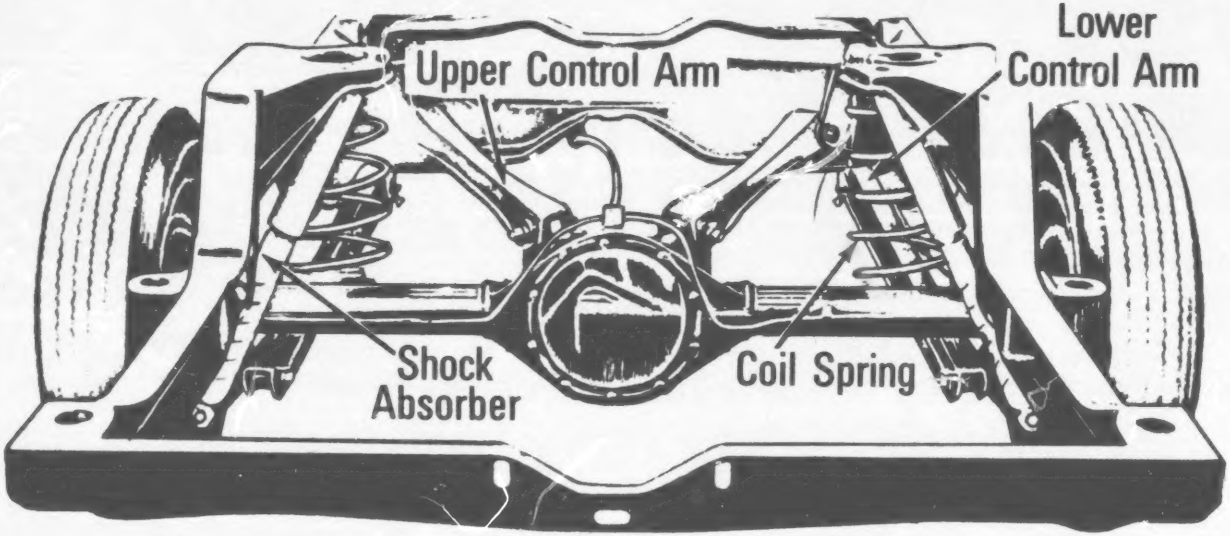
J. Leaf assembly

Solid Axle Leaf Spring Suspension

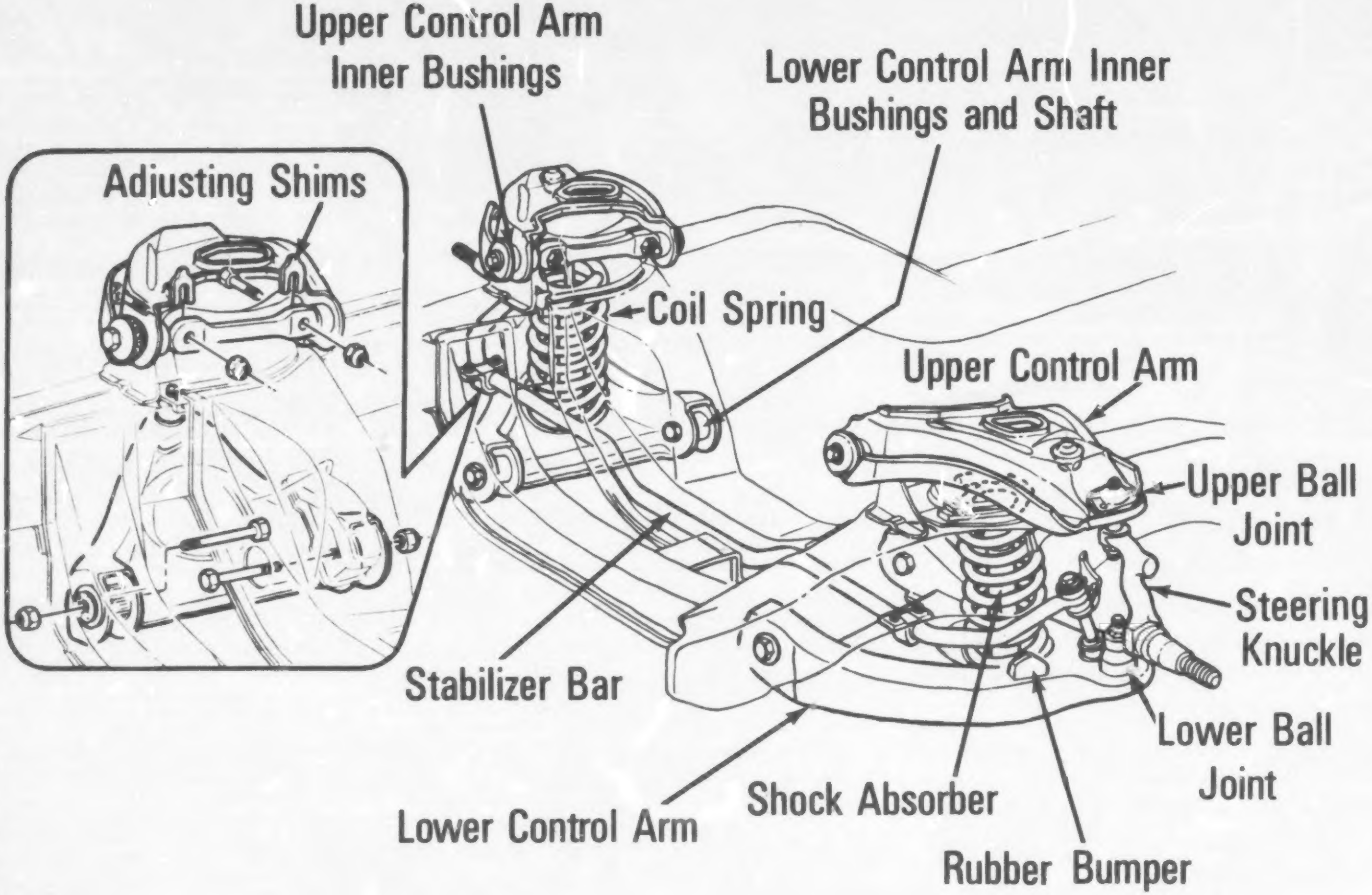

Front Axle
Shock Absorber
Spring Shackle
I-Beam Axle
Steering Knuckle and Kingpin


Rear Axle
Leaf Spring
Spring Shackle
Shock Absorber
Axle Assembly
Propeller Shaft
Front Mount

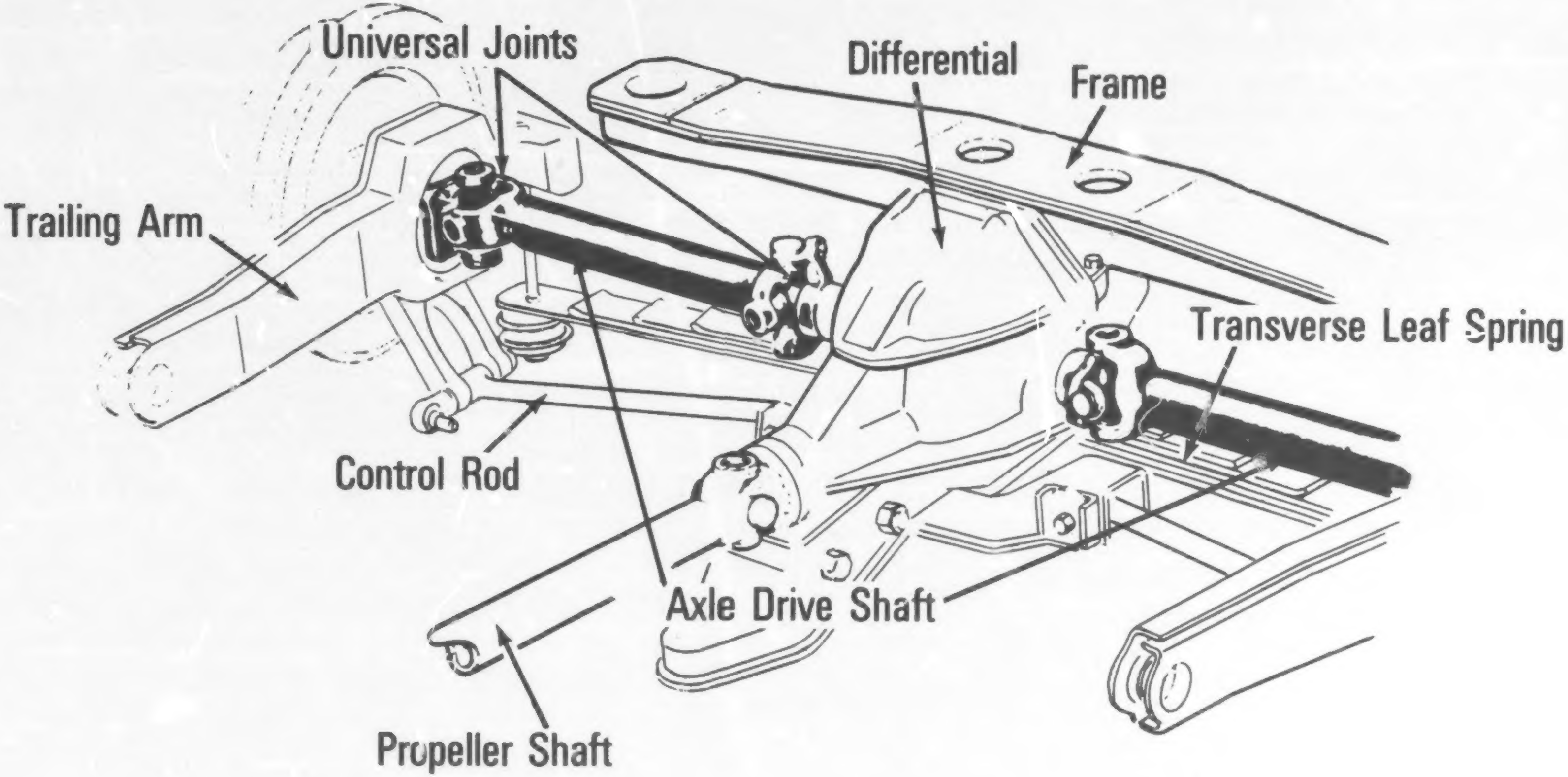
Solid Axle Coil Spring Suspension


Upper Control Arm
Lower Control Arm
Shock Absorber
Coil Spring

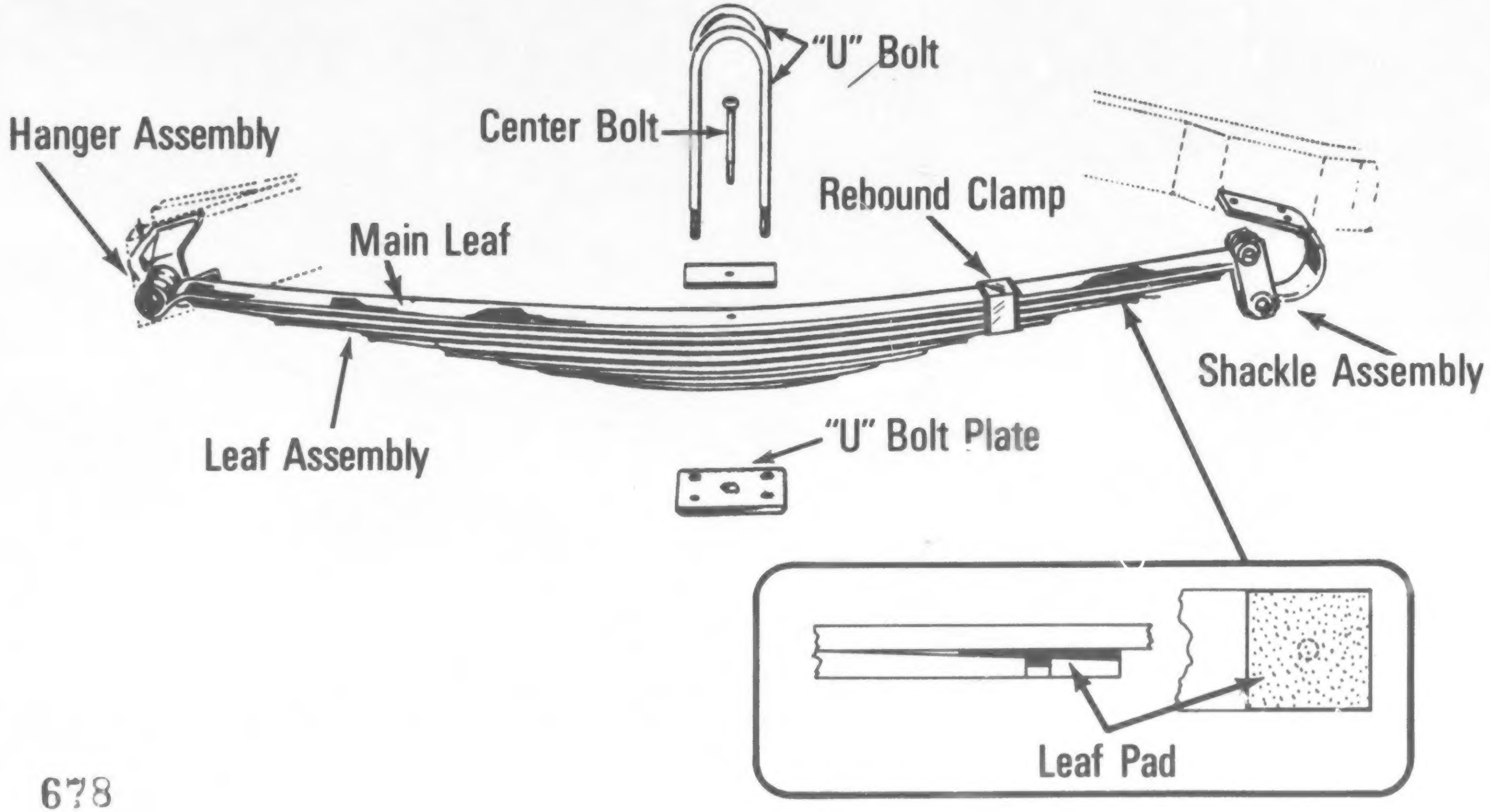
Independent Front Suspension


Upper Control Arm Inner Bushings
Lower Control Arm Inner Bushings and Shaft
Adjusting Shims
Coil Spring
Upper Control Arm
Upper Ball Joint
Steering Knuckle
Stabilizer Bar
Lower Ball Joint
Shock Absorber
Lower Control Arm
Rubber Bumper

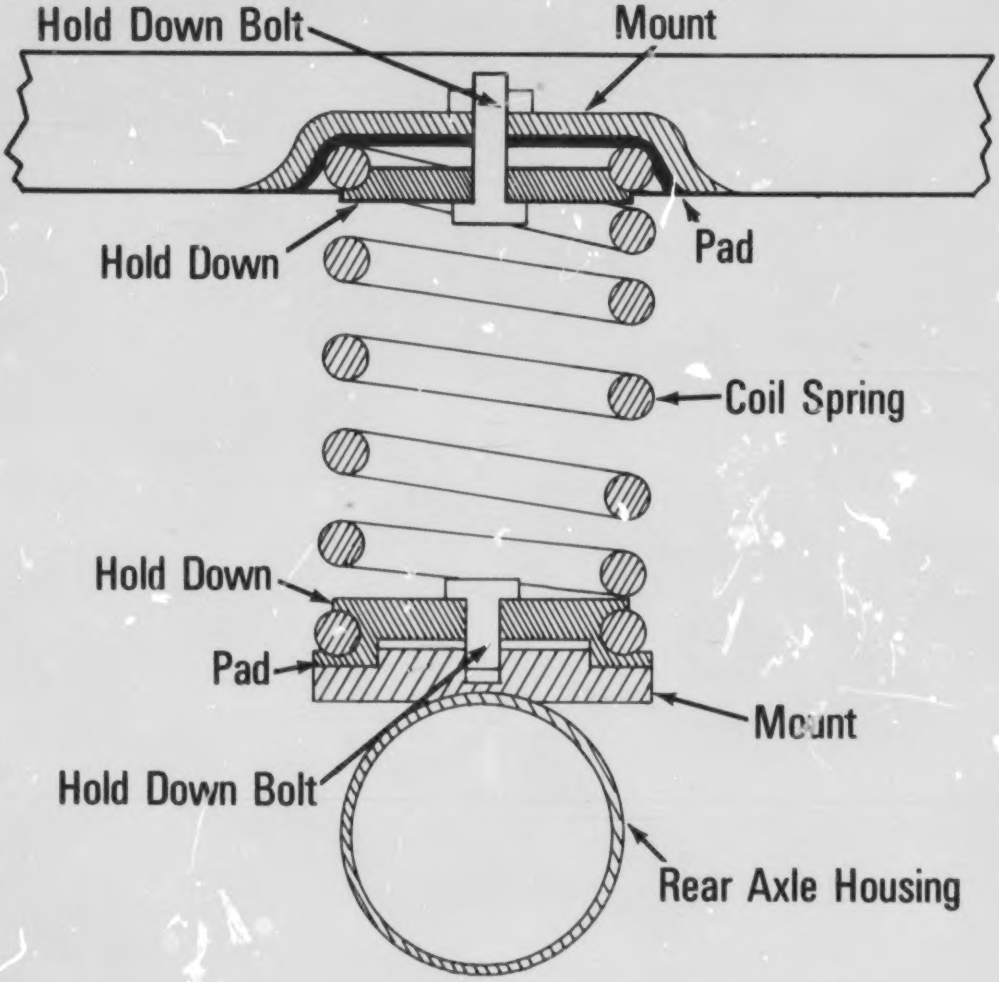
Independent Rear Suspension with Swing Axle


Universal Joints
Differential
Frame
Trailing Arm
Transverse Leaf Spring
Control Rod
Axle Drive Shaft
Propeller Shaft

Semielliptical Leaf Spring

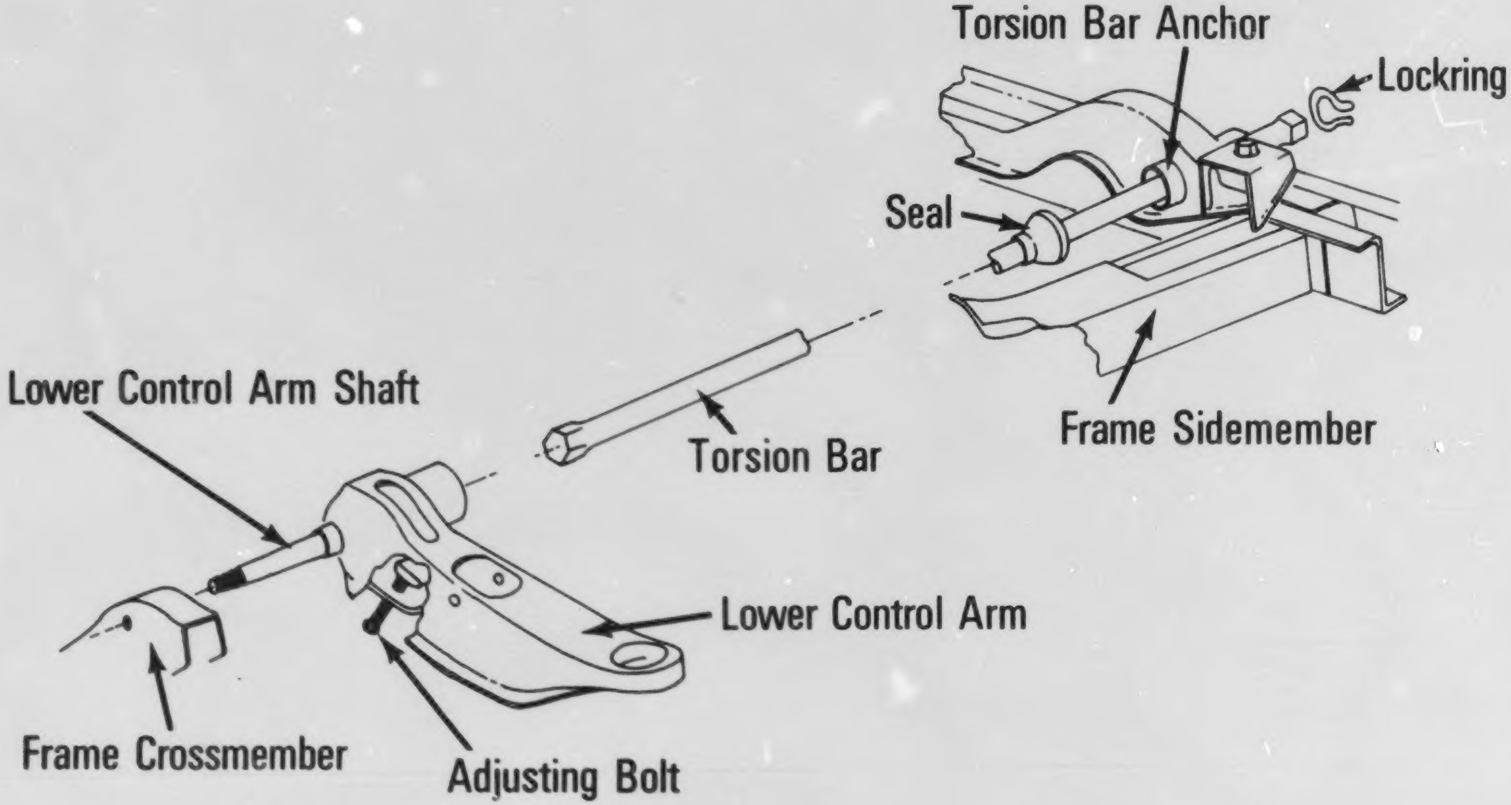

"U" Bolt
Center Bolt
Hanger Assembly
Rebound Clamp
Main Leaf
Shackle Assembly
Leaf Assembly
"U" Bolt Plate
Leaf Pad

Coil Spring

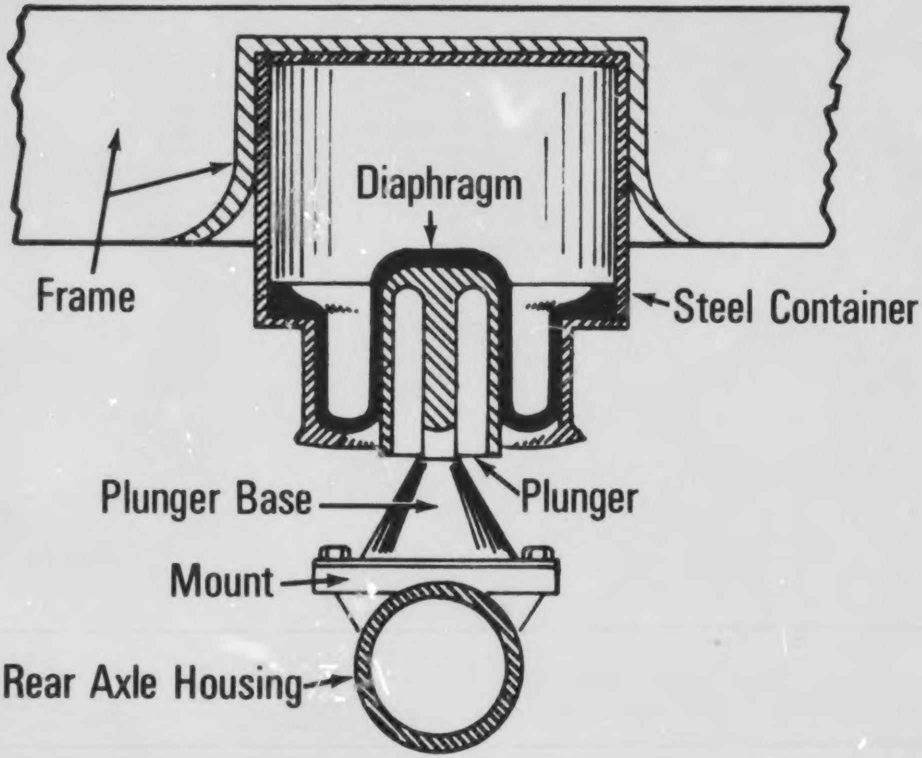

Hold Down Bolt
Mount
Pad
Hold Down
Coil Spring
Hold Down
Pad
Mount
Hold Down Bolt
Rear Axle Housing

AM I - 143-D

Torsion Bar Spring


Torsion Bar Anchor
Lockring
Seal
Frame Sidemember
Lower Control Arm Shaft
Torsion Bar
Lower Control Arm
Frame Crossmember
Adjusting Bolt

Air Spring


Diaphragm
Frame
Steel Container
Plunger Base
Plunger
Mount
Rear Axle Housing

SUSPENSION SYSTEM
UNIT V

JOB SHEET #1 INSPECT AND REPLACE SHOCK ABSORBERS

I. Tools and equipment

A. Floor jack

B. Jack stands

C. Fender covers

D. Special shock socket

E. Sockets, 7/16" - 3/4" (9 mm - 19 mm), 3/8" drive

F. Ratchet and extension, 3/8" drive

G. Combination end wrenches, 7/16" - 3/4" (9 mm - 19 mm)

H. Penetrating oil

II. Procedure

A. Inspect and test shock absorbers

1. Perform bounce test

(NOTE: This is a comparison test to help locate the suspected shock or noise condition.)

a. Place the vehicle on a level surface and remove excessive load

b. Bounce each corner of the vehicle by lifting up and pushing down on each end of the bumper until maximum up and down movement is reached

(NOTE: Bounce only one corner at a time.)

c. Let go of the bumper and observe the number of bounces it takes to settle out

d. Compare the rear corners together and the front corners with each other

(NOTE: The shocks should settle out with no more than two up-down motions; one side should have approximately the same number as the other side.)

JOB SHEET #1

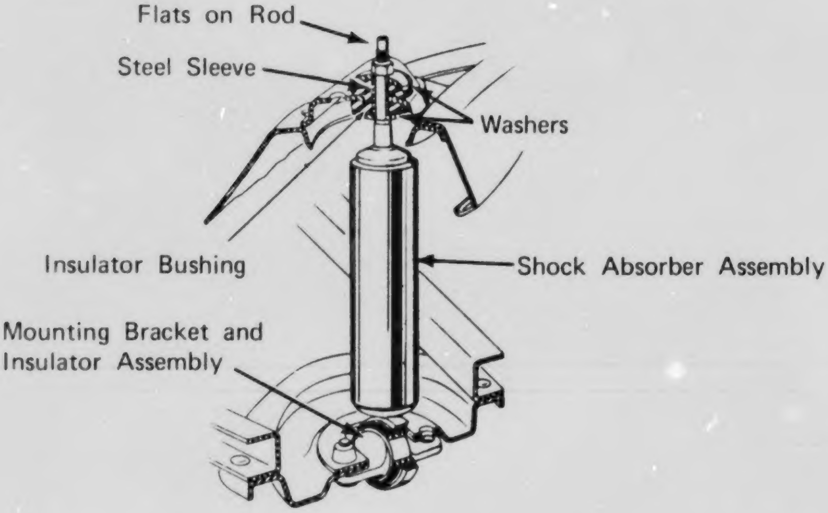
2. Inspect shock mounts

   a. Raise vehicle

   b. Place jack stands under the front lower control arms close to the ball joint and on the rear axle housing

   c. Inspect for worn or defective shock grommets (Figure 1)

FIGURE 1


Flats on Rod
Steel Sleeve
Washers
Insulator Bushing
Shock Absorber Assembly
Mounting Bracket and Insulator Assembly

   d. Check for loose bolts or mounting brackets

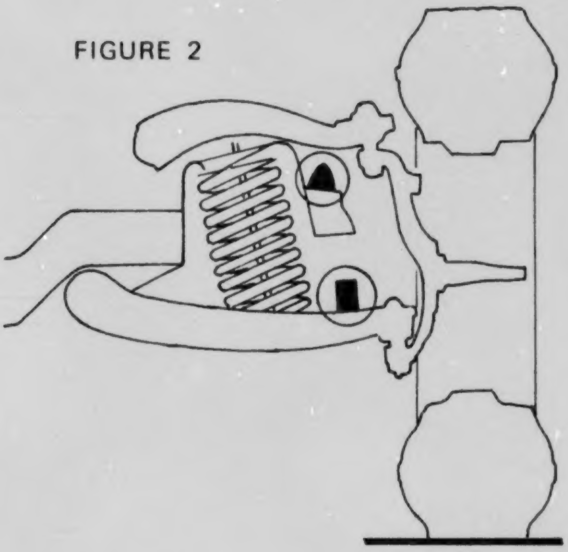
      (NOTE: See Figure 1.)

   e. Check for possible interference with other parts

JOB SHEET #1

(NOTE: Missing suspension bumper stops can contribute to noise and allow shocks to be damaged from severe bottoming of shock piston. See Figure 2.)

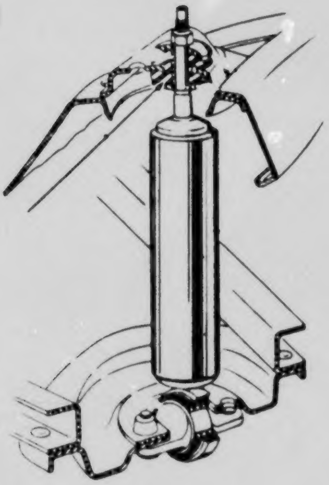
FIGURE 2



3. Operate shocks manually for final evaluation

   a. Disconnect the lower shock mount (Figure 3)

FIGURE 3



JOB SHEET #1

b. Pull the shock to the fully extended position

c. Check for hydraulic fluid leaking around the piston rod seal

(NOTE: The shock seal is engineered to permit the piston rod to retain a light film of lubricant normally; therefore, a damp area around the seal is not reason enough to replace the shock.)

d. Pump the shock by hand to check for

1) Internal binding or noise

2) Weak resistance to the force exerted against the shock

(NOTE: The shock should move slowly and smoothly through its full travel as you exert full force against it. The collapsing stroke will have slightly less resistance than the expanding stroke.)

B. Remove and replace a front shock absorber

1. Apply penetrating oil to fastener threads

2. Remove the retainer nut from the top mount of the shock

(NOTE: Use the special socket to hold the shock stud bolt.)

3. Remove the bolts retaining the lower end of the shock

4. Remove the shock

5. Remove any grommets that may have remained in the brackets

6. Install new grommets either in the frame or on the shock, depending on the type of grommet

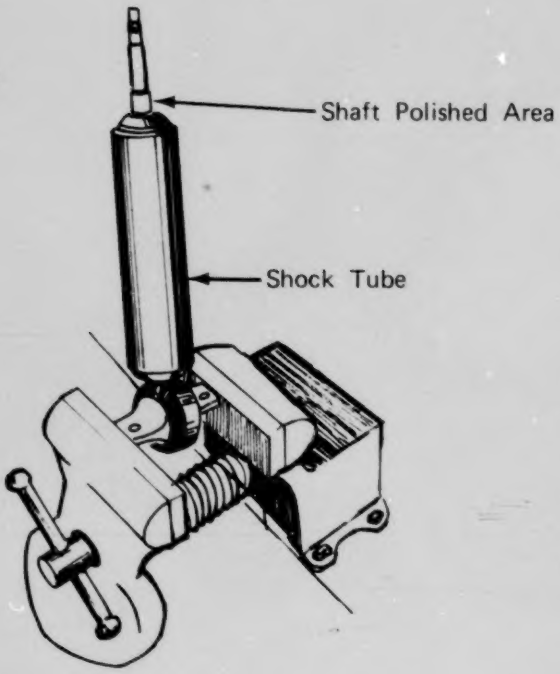
7. Air bleed the new shock before installation by clamping it upside down vertically in a vise and pumping the full travel of the shock at least three times

(NOTE: Some shocks may be bled best by being kept vertical in a right side up position and pumped through full travel at least three times.)

JOB SHEET #1

(CAUTION: Never clamp the shock on the tube portion or shaft polished area. See Figure 4.)

FIGURE 4



8. Reinstall the shock, making sure the retainer washers and the grommets are still in place
9. Attach the top mount and tighten the nut to the proper torque
10. Install locking pal nut if a self-locking nut is not used on the shock mount
11. Attach the lower mount and torque the bolts
12. Check for shock interference
13. Lower vehicle to the floor
14. Road test with the instructor

SUSPENSION SYSTEM
UNIT IV

JOB SHEET #2--INSPECT FRONT SUSPENSION FOR WEAR

I. Tools and equipment

- A. Floor jack
- B. Suitable jack stands
- C. Pry bar

II. Procedure

- A. Support vehicle to unload the pressure on the ball joints (Figure 1a or 1b)

FIGURE 1a

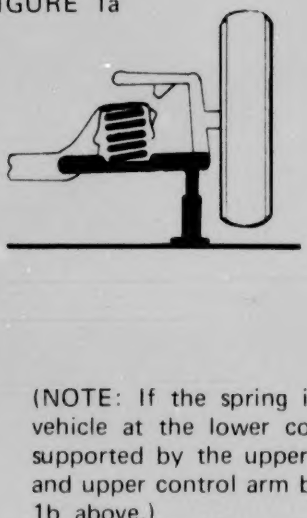
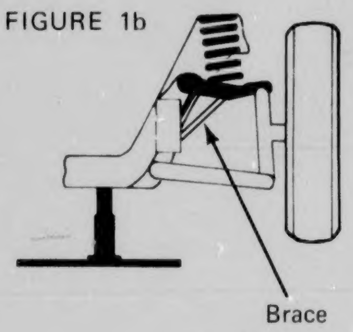


FIGURE 1b



(NOTE: If the spring is supported by the lower control arm, hoist the vehicle at the lower control arm as in Figure 1a above. If the spring is supported by the upper control arm, install a support between the frame and upper control arm before hoisting the vehicle at the frame as in Figure 1b above.)

- B. Remove hubcap
- C. Remove wheel hub dust cover
- D. Adjust wheel bearings
- E. Check the ball joints in the following manner and compare with manufacturer's specifications
    - 1. Rock tire top and bottom; reject if movement at tire sidewall exceeds maximum tolerance (Figure 2a or 2b)

JOB SHEET #2

(NOTE: Do not confuse wheel bearing looseness with ball joint wear.)

FIGURE 2a

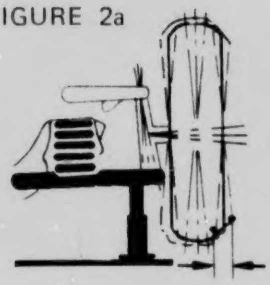
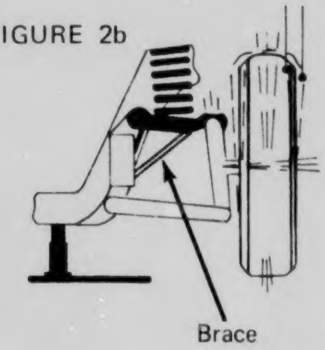


FIGURE 2b



2. Check axial movement; reject if vertical play in ball joint exceeds maximum tolerance (Figure 3a or 3b)

FIGURE 3a

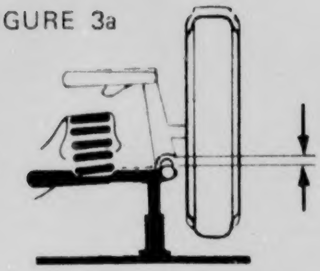
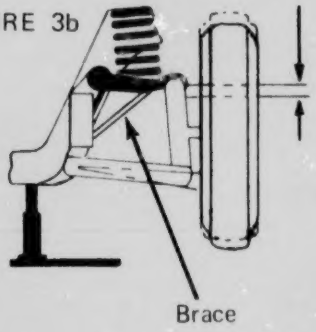


FIGURE 3b



F. Check inner bushings on the control arms

1. Inspect condition of rubber in bushing

2. Check the tightness of retaining bolts or nuts

JOB SHEET #2

3. Use a pry bar to check for lateral movement of the control arm in relation to the frame (Figure 4a or 4b)

FIGURE 4a

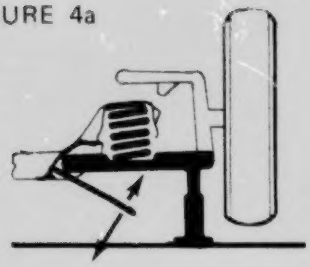
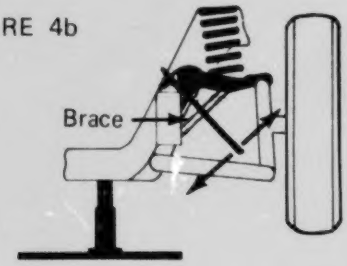


FIGURE 4b



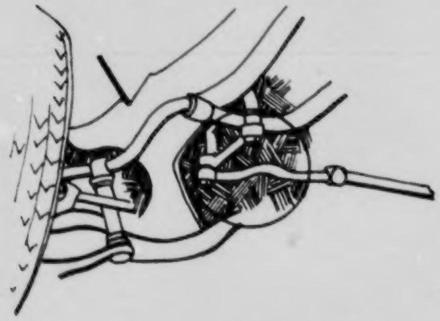
G. Check strut rods and stabilizer bar

1. Inspect rubber bushings and grommets

2. Inspect mounts and retaining bolts

3. Inspect for bent or broken bar or rods (Figure 5)

FIGURE 5



H. Replace parts as necessary to restore suspension to proper condition

SUSPENSION SYSTEM
UNIT IV

JOB SHEET #3--REPAIR AN UPPER CONTROL ARM ASSEMBLY ON A LOWER CONTROL ARM MOUNTED COIL SPRING

I. Tools and equipment

A. Floor jack

B. Jack stands

C. Combination end wrenches, 3/8" - 15/16" (8 mm - 24 mm)

D. Sockets, 1/2" drive, 3/8" - 15/16" (8 mm - 24 mm)

E. Ratchet wrench, 1/2" drive

F. Extension bar, 1/2" drive, 6" (150 mm) long

G. Suitable ball joint stud remover

H. Suitable inner control arm bushing press tools

I. Cold chisel or air hammer and chisel

J. Pry bar

K. Hammer

L. Diagonal cutting pliers

M. Pin punch, 3/16" (4.75 mm) shank

II. Procedure

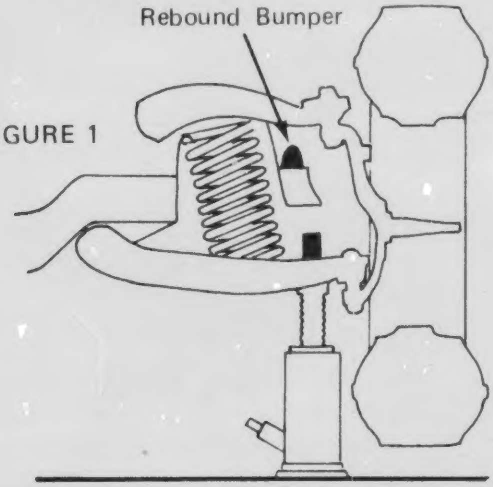
A. Raise vehicle and place on jack stands so that the stands are as far out on the lower control arms as possible

B. Remove the tire and wheel assembly

JOB SHEET #3

C. Remove the rebound bumper from upper control arm (Figure 1)

FIGURE 1



D. Remove the cotter pin from upper ball joint stud

E. Loosen, but do not remove, ball stud nut

(NOTE: See Figure 2.)

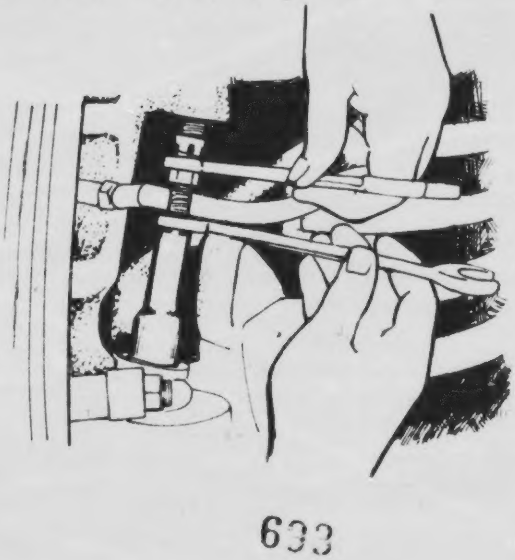
F. Break the joint loose between the tapered ball stud and tapered hole in the steering knuckle using one of the methods below

1. Using a special removal tool to apply pressure to the ball stud

   (NOTE: Do not attempt to break the joint with the tool force only; this will damage the tool.)

   a. Install the tool (Figure 2)

FIGURE 2

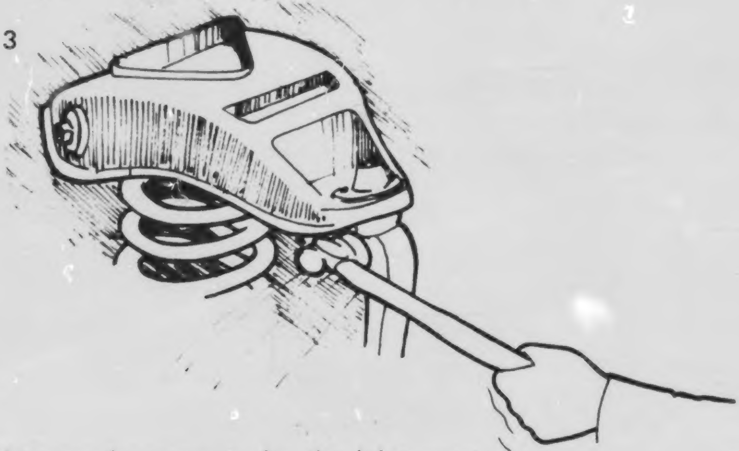


JOB SHEET #3

b. Tighten the tool until it is under strong tension

c. Rap the stud area of the steering knuckle sharply with a hammer to jar the joint loose (Figure 3)

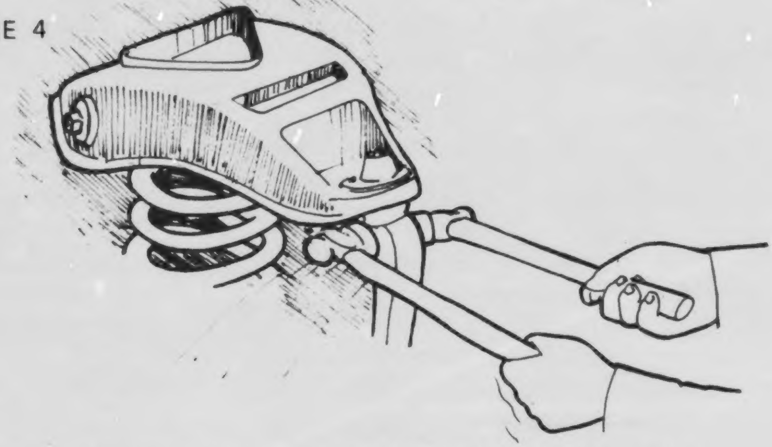
FIGURE 3



2. Using two hammers to jar the joint apart

(NOTE: The back-up hammer should be equal to or heavier than the striking hammer. See Figure 4.)

FIGURE 4



G. Remove the inner control arm bushing shaft attaching bolts

(NOTE: If caster-camber shims are used, keep the two shim packs separated to aid reassembly and alignment.)

H. Remove the ball stud nut

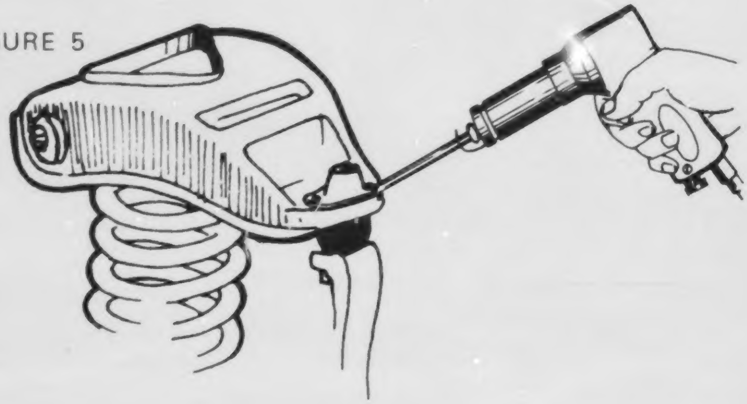
I. Remove the upper control arm assembly

JOB SHEET #3

J. Place the control arm assembly in a vise or holding fixture

K. Use a cold chisel or air hammer and chisel to cut the ball joint rivet heads (Figure 5)

FIGURE 5



L. Drive out the rivet shafts with a pin punch and remove the ball joint

M. Clean the control arm and remove any burrs from the ball joint mounting area

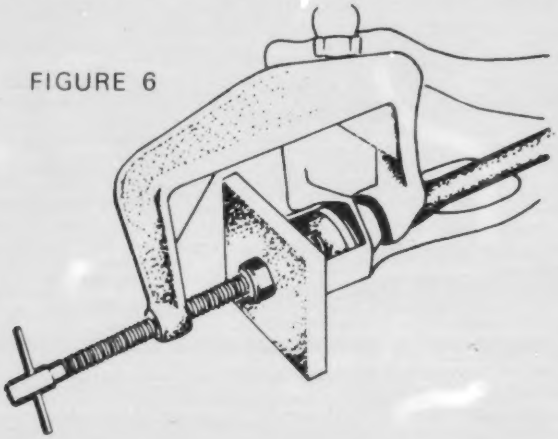
N. Place the new ball joint on control arm and secure with the special bolts provided

(NOTE: These bolts should be properly torqued to avoid being damaged.)

O. Remove the inner control arm pivot shaft retaining bolts or nuts

P. Use a suitable press tool to remove one of the bushings (Figure 6)

FIGURE 6



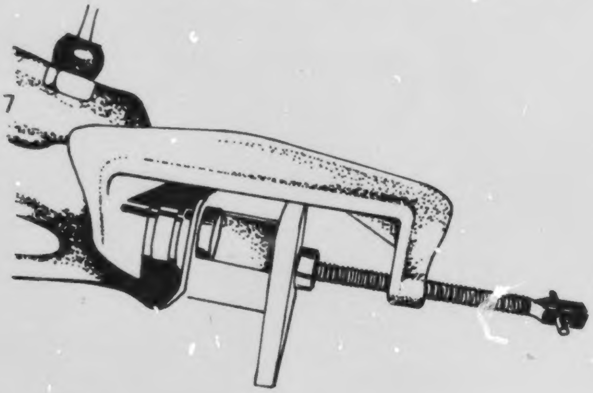
JOB SHEET #3

Q. Remove the pivot shaft

(NOTE: Remember the position of the shaft so that it can be reinstalled correctly.)

R. Press out the other bushing (Figure 7)

FIGURE 7



S. Press in one new bushing

T. Install pivot shaft in the orginal position

U. Press in the other new bushing

V. Install retaining washers and bolts or nuts

(CAUTION: Suspension rubber bushing retainer bolts should not be tightened until the vehicle is sitting on its wheels.)

W. Install upper control arm assembly on the vehicle

X. Install pivot shaft to frame attaching bolts

Y. Insert caster-camber shims in the same position as they were removed

Z. Torque the pivot shaft retaining bolts

AA. Place the ball stud in the steering knuckle and torque

BB. Cotter pin the ball stud nut

CC. Install rebound rubber bumper in upper control arm

DD. Replace tire and wheel assembly

JOB SHEET #3

EE. Lower vehicle to the floor

FF. Bounce the front end of the vehicle several times and let it settle out

GG. Tighten the pivot shaft to bushing retaining bolts or nuts

HH. Align the front end

SUSPENSION SYSTEM
UNIT IV

JOB SHEET #4--REPAIR A LOWER CONTROL ARM ASSEMBLY ON A LOWER CONTROL ARM MOUNTED SPRING

I. Tools and equipment

  A. Floor jack

  B. Jack stands

  C. Combination end wrenches, 3/8" - 15/16" (8 mm - 24 mm)

  D. Sockets, 1/2" drive, 3/8" - 15/16" (8 mm - 24 mm)

  E. Ratchet wrench, 1/2" drive

  F. Extension bar, 1/2" drive, 6" (150 mm) long

  G. Suitable tool to remove ball joint stud bolt

  H. Suitable press tool for ball joint

  I. Suitable press tool for pivot bushings

  J. Pry bar

  K. Hammer

  L. Diagonal cutting pliers

  M. Adjustable wrench, 10"

  N. Grease cap tool

  O. Spring compressor tool

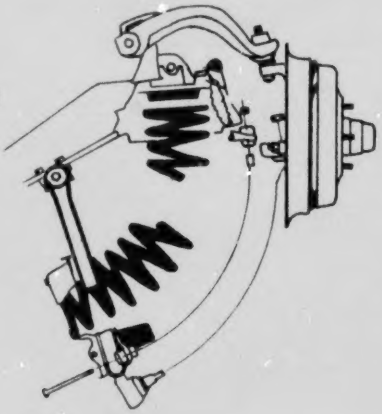
II. Procedure

  A. Raise vehicle and place jack stands on frame

JOB SHEET #4

(NOTE: The vehicle needs to be high enough off the floor to allow the lower control arm to swing down without striking the floor. See Figure 1.)

FIGURE 1



B. Remove tire, wheel, and brake drum assembly

(NOTE: On some models it will be necessary to remove the brake backing plate to allow removal of ball joints.)

C. Remove shock absorber

(NOTE: On some models disconnect only the lower end of the shock and push it up out of the way.)

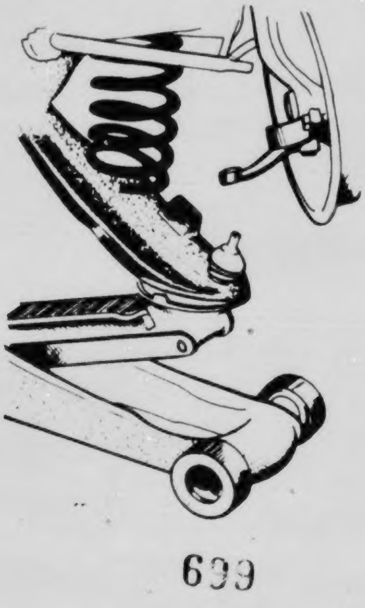
D. Disconnect stabilizer bar at the control arm

E. Disconnect strut rod from control arm if so equipped

F. Disconnect the tie rod from the steering arm

G. Place a floor jack under the control arm parallel with the arm (Figure 2)

FIGURE 2



JOB SHEET #4

H. Raise the control arm outer end enough to take pressure off the lower ball joint

(NOTE: See Figure 2.)

I. Remove the cotter pins from both ball joint stud bolts

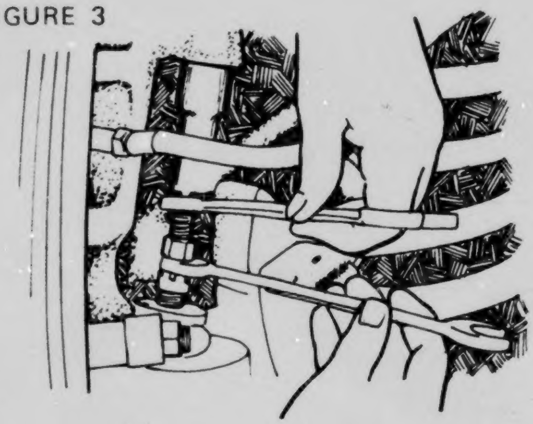
J. Loosen lower stud nut approximately two turns

(NOTE: Do not remove at this time.)

K. Install the special ball stud bolt remover tool (Figure 3)

(NOTE: The tool should push squarely against the ball studs.)

FIGURE 3

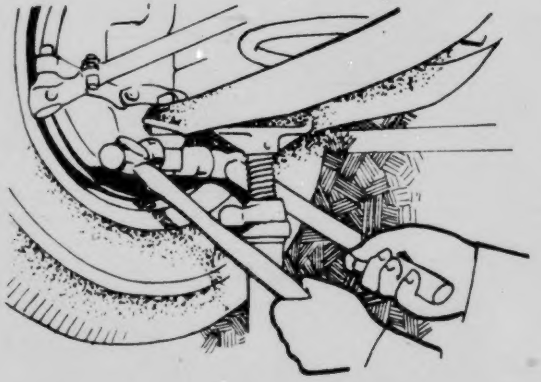


L. Tighten the tool until the studs are under tension

(CAUTION: Do not attempt to break the joint with tool pressure only; this could damage the tool.)

M. Tap the steering spindle sharply with a hammer near the lower stud to loosen the stud from the spindle (Figure 4)

FIGURE 4



JOB SHEET #4

(CAUTION: Safety chain the coil spring to the lower control arm to prevent spring from slipping.)

N. Remove the ball joint stud nut

O. Lower the control arm slowly with the jack

(CAUTION: Under pressure, the coil spring is very strong and potentially dangerous. Use extreme care when working with it.)

P. Remove the jack

Q. Remove the safety chain and spring

R. Remove the control arm pivot bushing bolts and remove the control arm from the vehicle

S. Remove ball joint from the control arm with a hydraulic press and suitable tools (Figure 5)

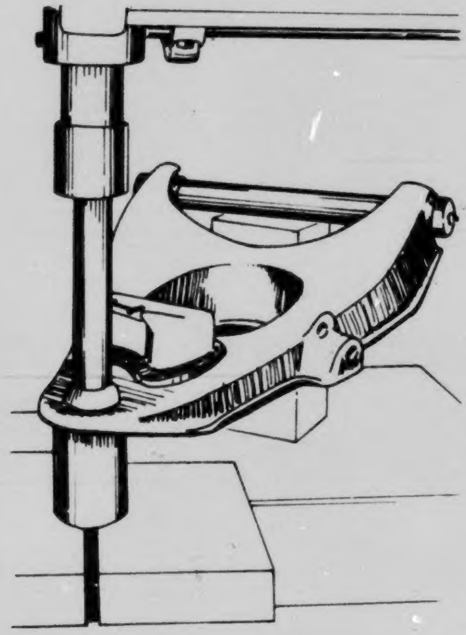


FIGURE 5

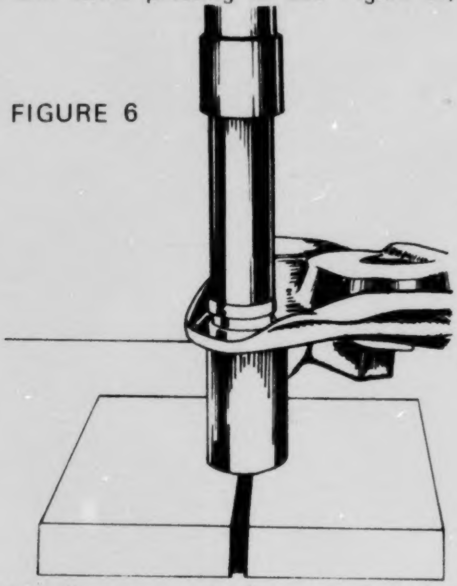
JOB SHEET #4

T. Clean the control arm and remove any burrs in the ball joint seat area

U. Press the new ball joint into the control arm

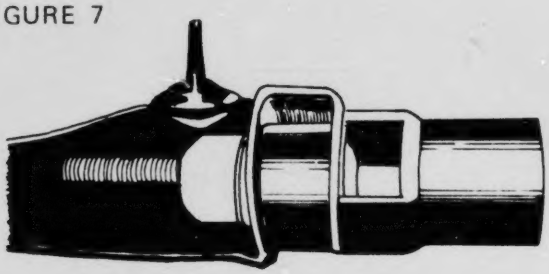
(NOTE: To prevent damage to the arm, carefully align the ball joint with the control arm while pressing it. See Figure 6.)

FIGURE 6



V. Use a suitable puller or press tool to remove the control arm inner bushings (Figure 7)

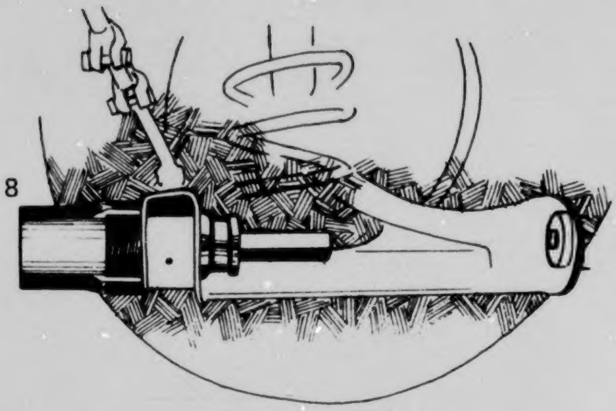
FIGURE 7



JOB SHEET #4

W. Press new bushings into the control arm until they are properly seated (Figure 8)

FIGURE 8



X. Position the control arm properly into the frame and insert pivot bolts

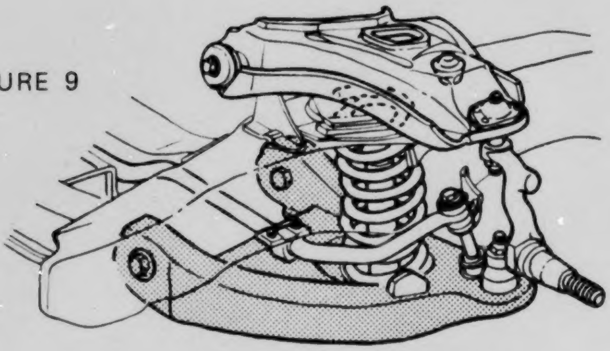
(NOTE: Do not tighten pivot bolts until the vehicle is sitting on its tires at normal height.)

Y. Place a floor jack under the control arm so that it is parallel to the arm and will lift against the ball joint area

Z. Install the coil spring top into the frame spring well

AA. Position the lower end of the spring on the control arm so that when the arm is raised the end of the coil is approximately 1/2 inch (12 mm) from the end of the groove in the spring seat (Figure 9)

FIGURE 9



JOB SHEET #4

BB. Secure the spring to the control arm with a safety chain

CC. Guide the spring into its seat while raising the control arm outer end into position

DD. Connect the ball joint to the steering knuckle

EE. Torque the ball stud nut; install cotter pin in both stud nuts

FF. Connect the stabilizer bar to lower control arm

GG. Replace shock absorber

HH. Connect strut rod if so equipped

II. Replace brake backing plate if it was removed

JJ. Reconnect the tie rod to the steering arm

(NOTE: Be sure to install a cotter pin in tie rod end.)

KK. Replace tire, wheel, and brake drum assembly

LL. Lower vehicle to the floor

MM. Bounce the front of the vehicle and let it settle out

NN. Tighten the control arm inner pivot bolts

OO. Align the front end

(CAUTION: Double check that all new cotter pins are in place.)

SUSPENSION SYSTEM
UNIT IV

TEST

1. State the two purposes of the suspension system.

   a.

   b.

2. Define the terms listed below.

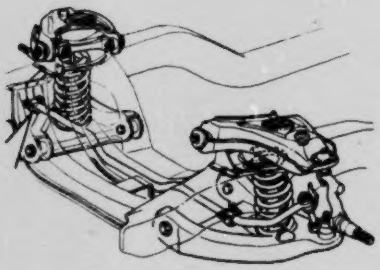
   a. Stabilizer bar

   b. S.L.A. type suspension (short-long arm)

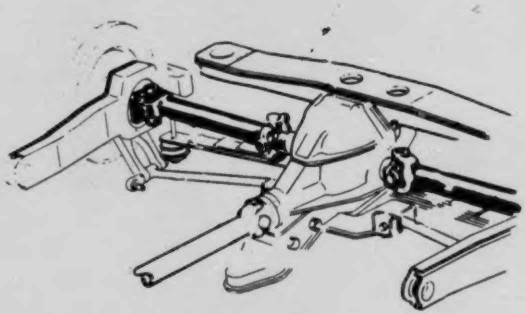
   c. Sprung weight

   d. Shock absorber

3. Identify the suspension systems in the diagrams below by writing the correct names in the blanks provided.



a.______________________________



b.______________________________

4. Identify the parts of the suspension system in the diagram below by placing the correct numbers in the blanks provided.

_____a. Upper control arm (short arm)

_____b. Coil spring

_____c. Upper ball joint

_____d. Shock absorber

_____e. Lower ball joint

_____f. Lower control arm (long arm)

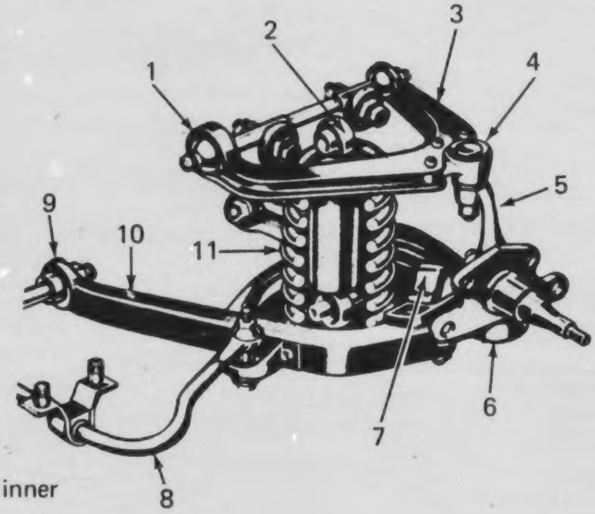
_____g. Steering knuckle

_____h. Rubber bumper

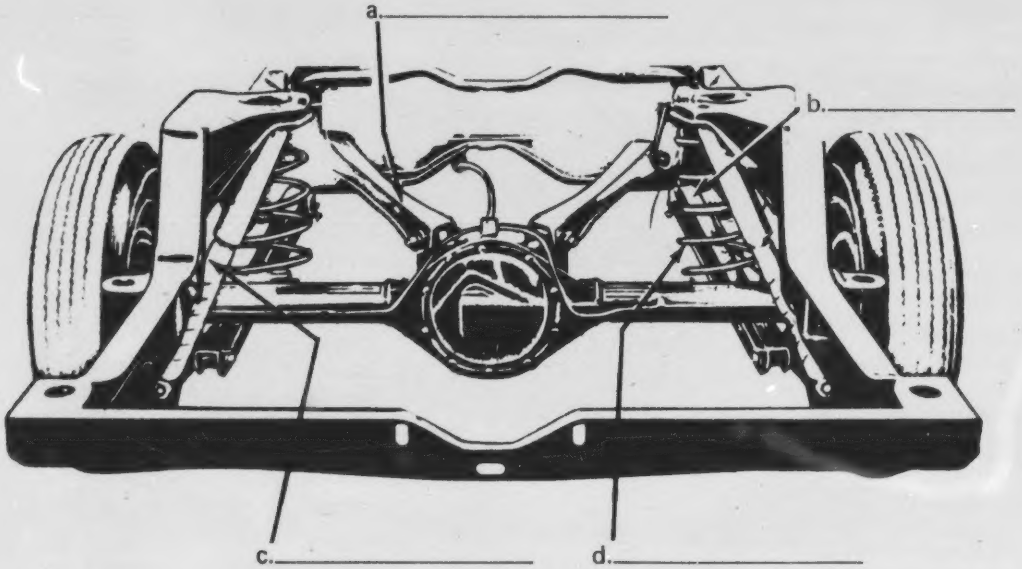
_____i. Stabilizer bar

_____j. Lower control arm inner bushings and shaft

_____k. Upper control arm inner bushings



5. Identify the parts of the suspension system in the diagram below by writing the correct names in the blanks provided.



6. Discuss the four types of suspension springs.

   a. Semielliptical leaf spring

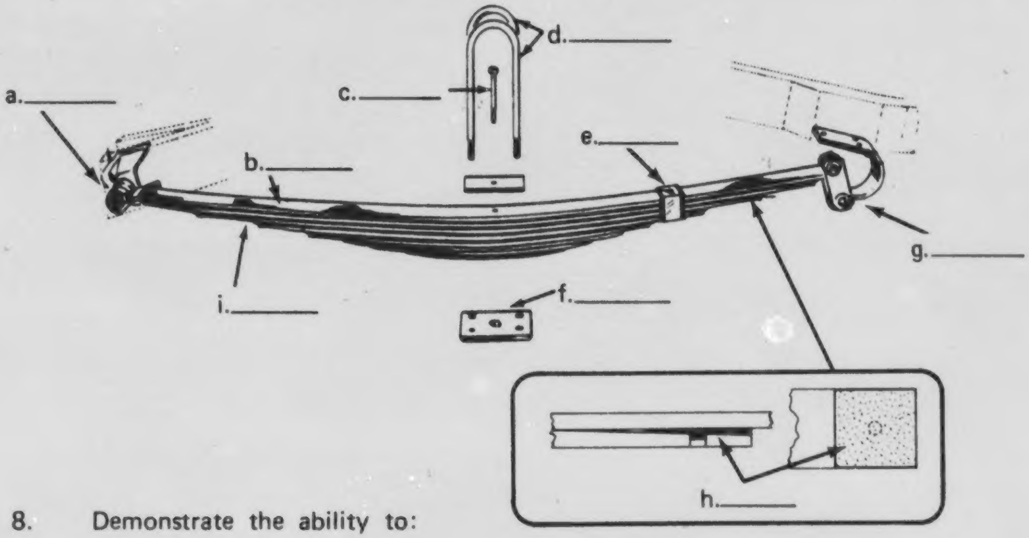
   b. Coil spring

   c. Torsion bar

   d. Air spring

7. Identify the parts of the leaf spring in the diagram below by placing the correct numbers in the blanks provided.

1. Main leaf	6. Center bolt
2. Leaf pad	7. U-bolt plate
3. Rebound clamp	8. U-bolts
4. Shackle assembly	9. Leaf assembly
5. Hanger assembly	



8. Demonstrate the ability to:

   a. Inspect and replace shock absorbers.

   b. Inspect a front suspension for wear.

   c. Repair an upper control arm assembly on a lower control arm mounted coil spring.

   d. Repair a lower control arm assembly on a lower control arm mounted spring.

   (NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

SUSPENSION SYSTEM
UNIT IV

ANSWERS TO TEST

1. a. To allow the vehicle to travel over irregular surfaces with a minimum amount of up-down movement to the body

   b. To allow the vehicle to corner with minimum roll or tendency to break friction between tire and road

2. a. Stabilizer bar--Transverse mounted spring steel bar that minimizes body lean or tipping while cornering

   b. S.L.A. type suspension (short-long arm)--Suspension system utilizing two control arms, with the upper arm shorter than the lower to allow the wheel to deflect up and down with a minimum change in camber

   c. Sprung weight--Weight of all vehicle parts supported by the springs

   d. Shock absorber--Hydraulic piston and cylinder device with one end attached to the frame and the other end attached to the axle to dampen or restrict the up-down movement of the springs

3. a. Independent front or S.L.A. control arm arrangement

   b. Independent rear with swing axle

4. a. 3

   b. 11

   c. 4

   d. 2

   e. 6

   f. 10

   g. 5

   h. 7

   i. 8

   j. 9

   k. 1

5. a. Upper control arm

   b. Lower control arm

   c. Shock absorber

   d. Coil spring

6. a. Semielliptical leaf spring--A number of flat steel springs of varying lengths bolted together in the center to make a single unit and attached to the vehicle body at each end by shackles and to the axle by U-bolts

   b. Coil spring--Special steel spring rod wound into a spiral coil, with one end secured to the frame and the other to the axle or control arm

   c. Torsion bar--Relatively long spring steel bar that has one end anchored to the frame and the other end anchored to the lower control arm which twists the bar to allow the vehicle body to move up and down

   d. Air spring--Cylinder and plunger separated by compressed air and placed between the axle and frame of the vehicle to provide a spring or cushion for the body of the vehicle

7. a. 5

   b. 1

   c. 6

   d. 8

   e. 3

   f. 7

   g. 4

   h. 2

   i. 9

8. Performance skills will be evaluated to the satisfaction of the instructor.

STEERING SYSTEM
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify parts of the steering system. The student should be able to inspect, repair, and adjust a manual steering system; pressure test power steering; and reseal a power steering pump. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Write the purposes of the steering system.
2. Match terms associated with steering systems to the correct definitions.
3. Identify parts of a steering system.
4. Name steering parts which should be inspected for wear, adjustment, and damage.
5. List types of manual steering gears.
6. Identify parts of a recirculating ball nut and worm manual steering gear.
7. List types of power steering pumps.
8. Describe types of power steering systems.
9. Demonstrate the ability to:
    a. Inspect a steering system for damaged parts or wear.
    b. Remove and replace a tie rod end.
    c. Pressure test a power steering system.
    d. Remove, reseal, and replace a power steering pump.
    e. Remove, recondition, and replace a recirculating ball type steering gear.

STEERING SYSTEM
UNIT V

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined on the job sheets.

   G. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Demonstrate the ability to accomplish the procedures outlined on the job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Parallelogram Steering Linkage and Ackerman Principle

      2. TM 2--Over Center High Point

      3. TM 3--Steering Columns

      4. TM 4--Parts of the Steering System

5. TM 5--Types of Manual Steering Gears

6. TM 6--Parts of a Recirculating Ball Nut and Worm

7. TM 7--Types of Power Steering Pumps

8. TM 8--Integral Power Steering System

9. TM 9--Linkage-Booster Power Steering System

10. TM 10--Semi-Integral Power Steering System

D. Job sheets

1. Job Sheet #1--Inspect a Steering System for Damaged Parts or Wear

2. Job Sheet #2--Remove and Replace a Tie Rod End

3. Job Sheet #3--Pressure Test a Power Steering System

4. Job Sheet #4--Remove, Reseal, and Replace a Power Steering Pump

5. Job Sheet #5--Remove, Recondition, and Replace a Recirculating Ball Type Steering Gear

E. Test

F. Answers to test

II. References:

A. Bacon, E. Miles. *Principles of Wheel Alinement Service.* New York: McGraw-Hill Book Co., 1971.

B. Stockel, Martin W. *Auto Service and Repair.* Homewood, Illinois: Goodheart-Willcox Co., 1969.

C. Toboldt, William K., and Johnson, Larry. *Motor Service's Automotive Encyclopedia.* South Holland, Illinois: Goodheart-Willcox Co., 1970.

D. *Chevrolet Service Manual.* Detroit, Michigan: Chevrolet Motor Division, General Motors Corporation, 1973.

E. *Plymouth Service Manual.* Detroit, Michigan: Chrysler-Plymouth Division, Chrysler Corporation, 1967.

F. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1971.

STEERING SYSTEM
UNIT V

INFORMATION SHEET

I. Purposes of the steering system

   A. To turn the front wheels of the vehicle right or left with minimum effort

   B. To maintain directional control

II. Terms and definitions

   A. Parallelogram steering linkage--Steering system utilizing two short tie rods connected to the steering arms and to a long center link; one end of the link is supported by an idler arm and the other end is attached to the pitman arm to form a parallelogram shape (Transparency 1)

   B. Ackerman principle--Bending the outer ends of the steering arms slightly inward so that when the vehicle is making a turn, the inside wheel will turn more sharply than the outside wheel; produces toe-out on turns (Transparency 1)

   C. Over center high point--Worm and sector gears are designed so that at the center of their travel the gear tooth mesh is at its closest tolerance (Transparency 2)

      (NOTE: All steering gear adjustments are performed with the gear at the over center high point position.)

   D. Power steering--Mechanical steering system that provides a hydraulic power assist unit to reduce the driver turning effort

   E. Constant ratio power steering--Steering gear with a fixed gear ratio throughout the total gear travel

   F. Variable ratio power steering--Steering gear that has a high ratio at center high point; the ratio decreases as the gear is turned in either direction

   G. Energy-absorbing steering column--Steering column that will collapse on impact to lessen the possibility of injury to the driver in an accident (Transparency 3)

   H. Function-locking or anti-theft steering column--Provides a positive lock on transmission gear selector as well as steering system

   I. Tilt wheel steering column--Steering column that allows the driver to change the vertical angle of the steering wheel (Transparency 3)

   J. Telescopic steering column--Steering column that allows the distance between the steering wheel and the driver to be adjusted (Transparency 3)

INFORMATION SHEET

III. Parts of a steering system (Transparency 4)

   A. Steering knuckle

   B. Steering arm

   C. Pitman arm

   D. Center link or relay link

   E. Idler arm

   F. Tie rod

   G. Steering gear

   H. Steering column

   (NOTE: The steering column may contain other components such as transmission gear selector, signal light switch, hazard warning light switch, and ignition switch.)

   I. Steering spindle bolt

IV. Steering parts to inspect for wear, adjustment, and damage

   A. Steering gear

   B. Steering column

   C. Steering linkage

   D. Steering arm

   E. Steering knuckle

V. Types of manual steering gears (Transparency 5)

   A. Recirculating ball nut and worm

   (NOTE: This is the most popular type.)

   B. Worm and sector

   C. Rack and pinion

VI. Parts of a recirculating ball nut and worm manual steering gear (Transparency 6)

   A. Steering shaft

   B. Steering shaft bearing adjuster

INFORMATION SHEET

C. Ball nut

D. Sector gear

E. Sector shaft adjusting screw

F. Sector shaft

G. Steering gear housing

H. Ball return guide

I. Steering shaft bearing (lower)

J. Sector shaft bearing

K. Steering shaft bearing adjuster lock nut

L. Ball return guide clamp

M. Steering shaft bearing (upper)

VII. Types of power steering pumps (Transparency 7)

A. Rotary gear

B. Vane

(NOTE: The three types of vane pumps are blade, roller, and slipper.)

VIII. Types of power steering systems (Transparencies 8, 9, and 10)

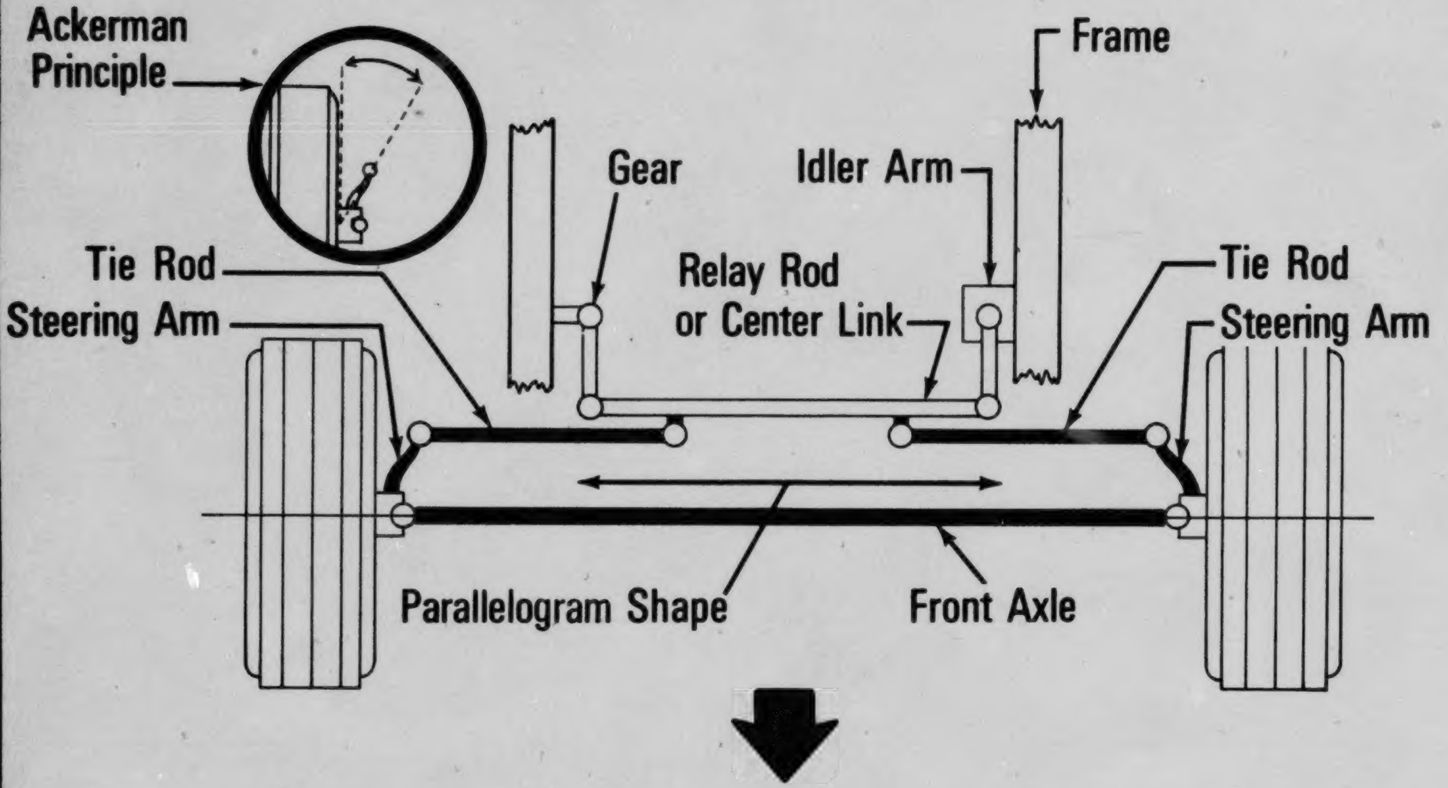
A. Integral--Power cylinder and control valve built into the gear housing

B. Linkage-booster--Power cylinder and control valve mounted on the steering linkage

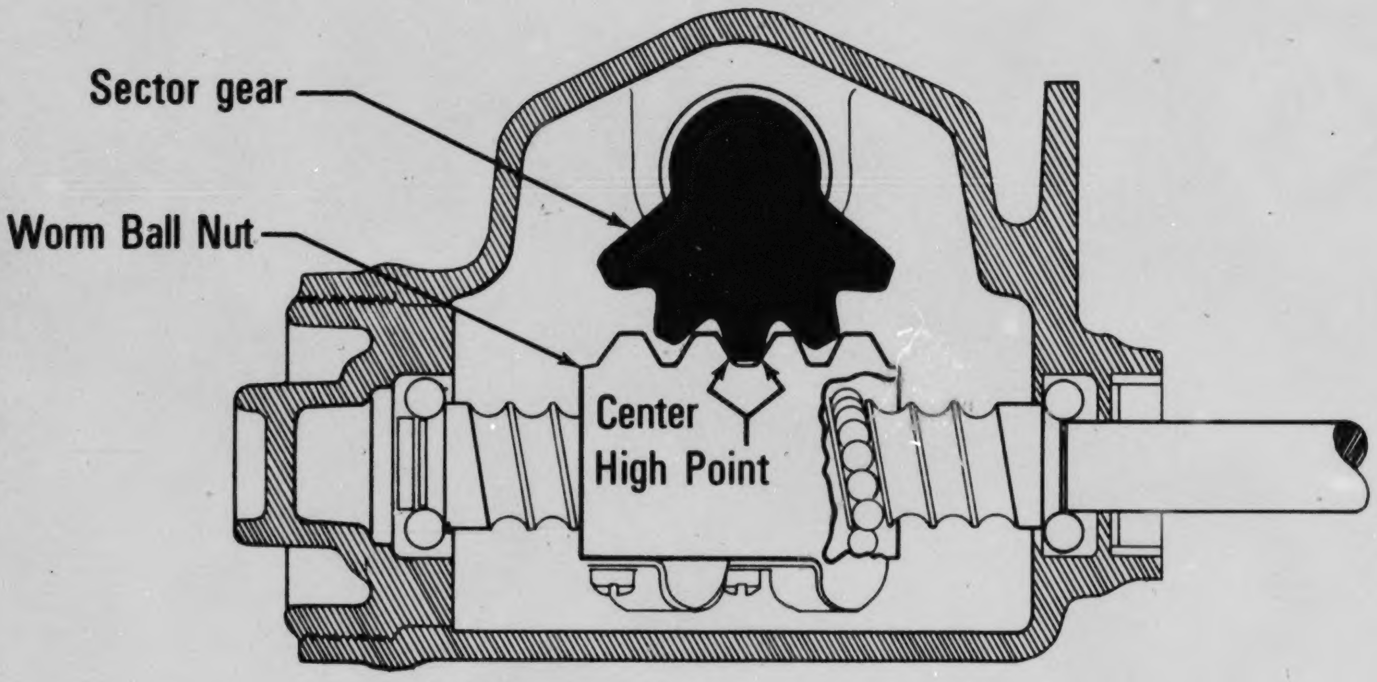
C. Semi-integral--Power cylinder attached to the steering linkage; control valve built into the steering gear housing

(NOTE: The semi-integral steering system is used mostly on trucks and heavy equipment.)

Parallelogram Steering Linkage and Ackerman Principle


Ackerman Principle
Frame
Gear
Idler Arm
Tie Rod
Relay Rod or Center Link
Tie Rod
Steering Arm
Steering Arm
Parallelogram Shape
Front Axle

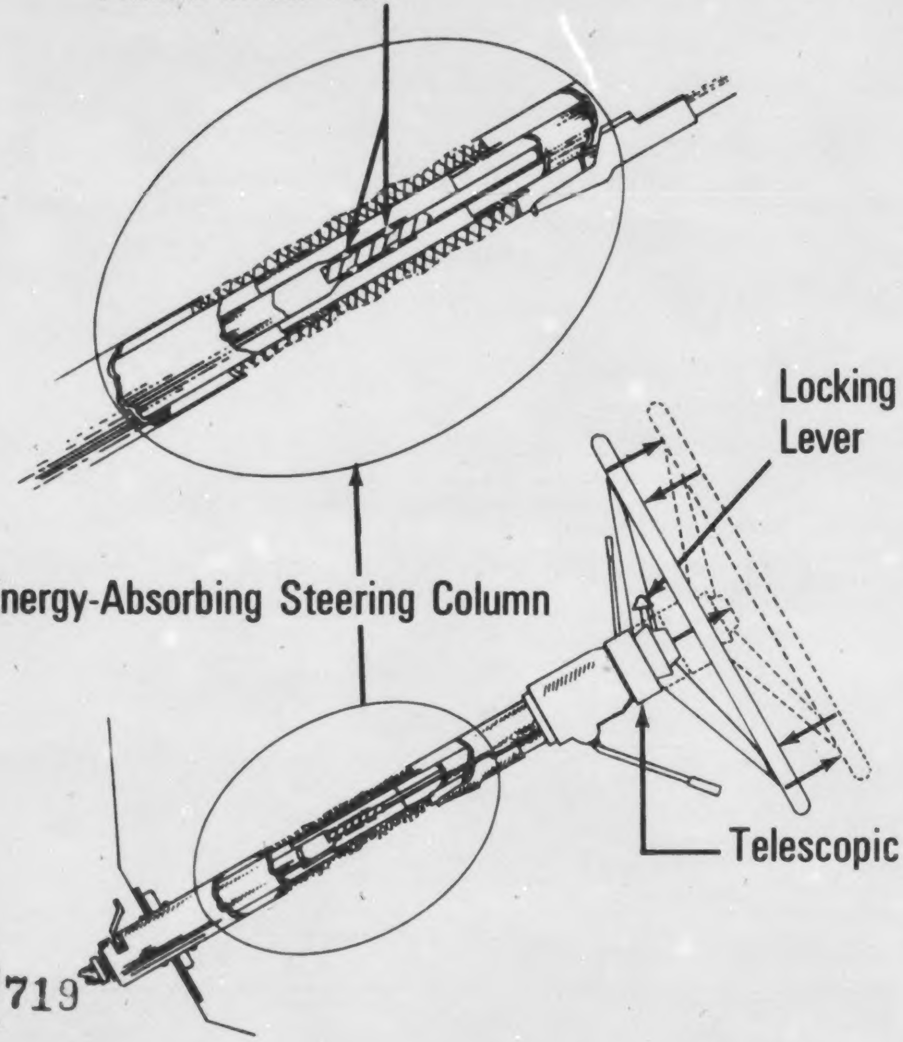
Over Center High Point

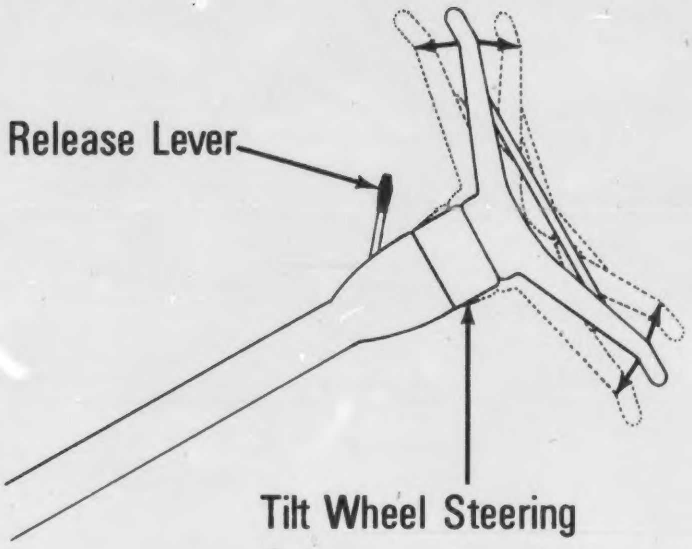

Sector gear
Worm Ball Nut
Center
High Point

Zero lash between gear teeth at over center high point

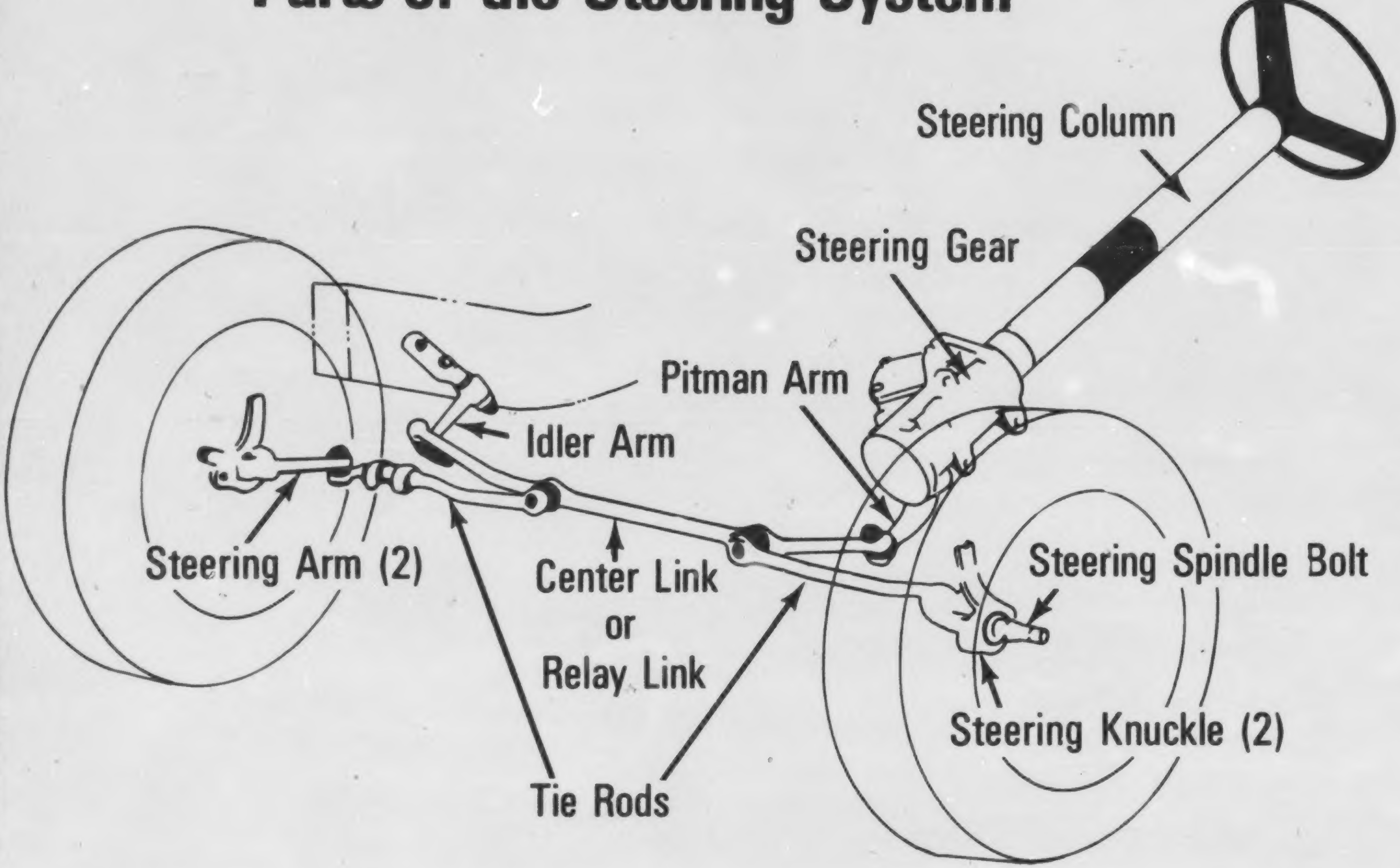
Lash between gear teeth increases as the sector is turned in either direction

Steering Columns


Plastic Sheer Pins
Energy-Absorbing Steering Column
Locking Lever
Telescopic Steering Column


Release Lever
Tilt Wheel Steering Column

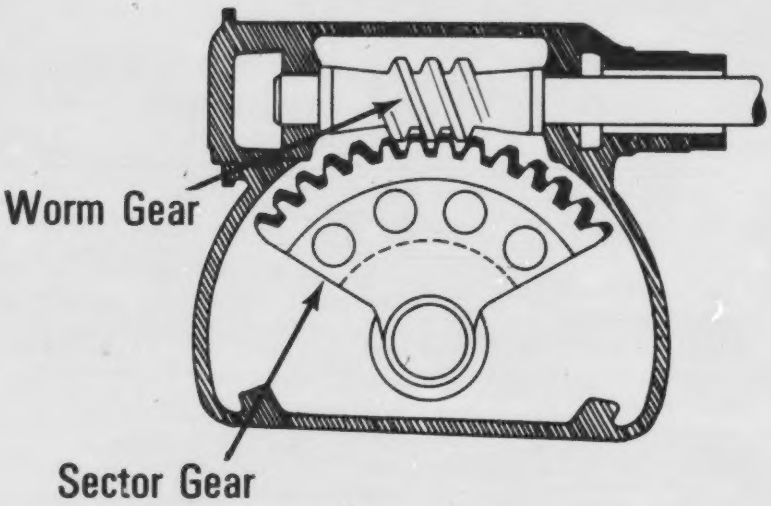
Parts of the Steering System


Steering Column
Steering Gear
Pitman Arm
Idler Arm
Steering Arm (2)
Center Link
or
Relay Link
Steering Spindle Bolt
Steering Knuckle (2)
Tie Rods

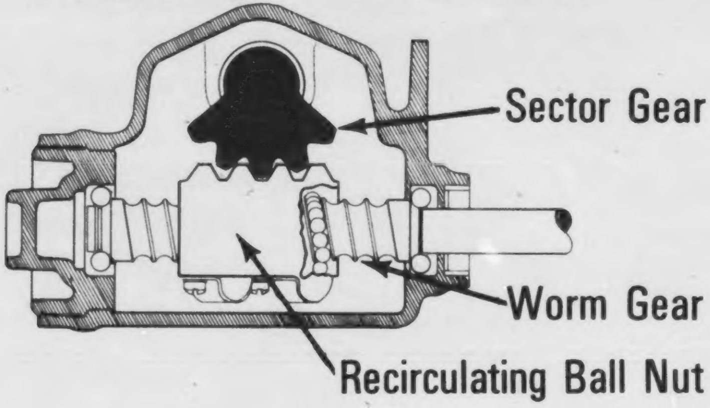
AM I - 193-D

Types of Manual Steering Gears

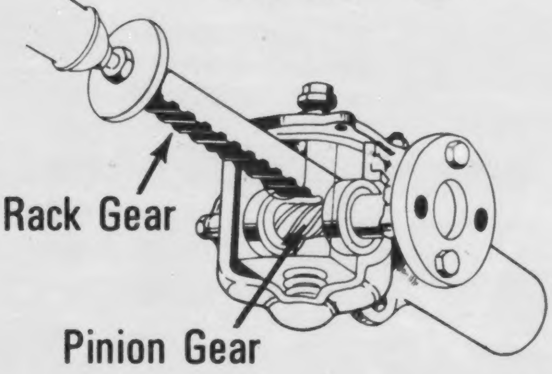
Worm and Sector


Worm Gear
Sector Gear

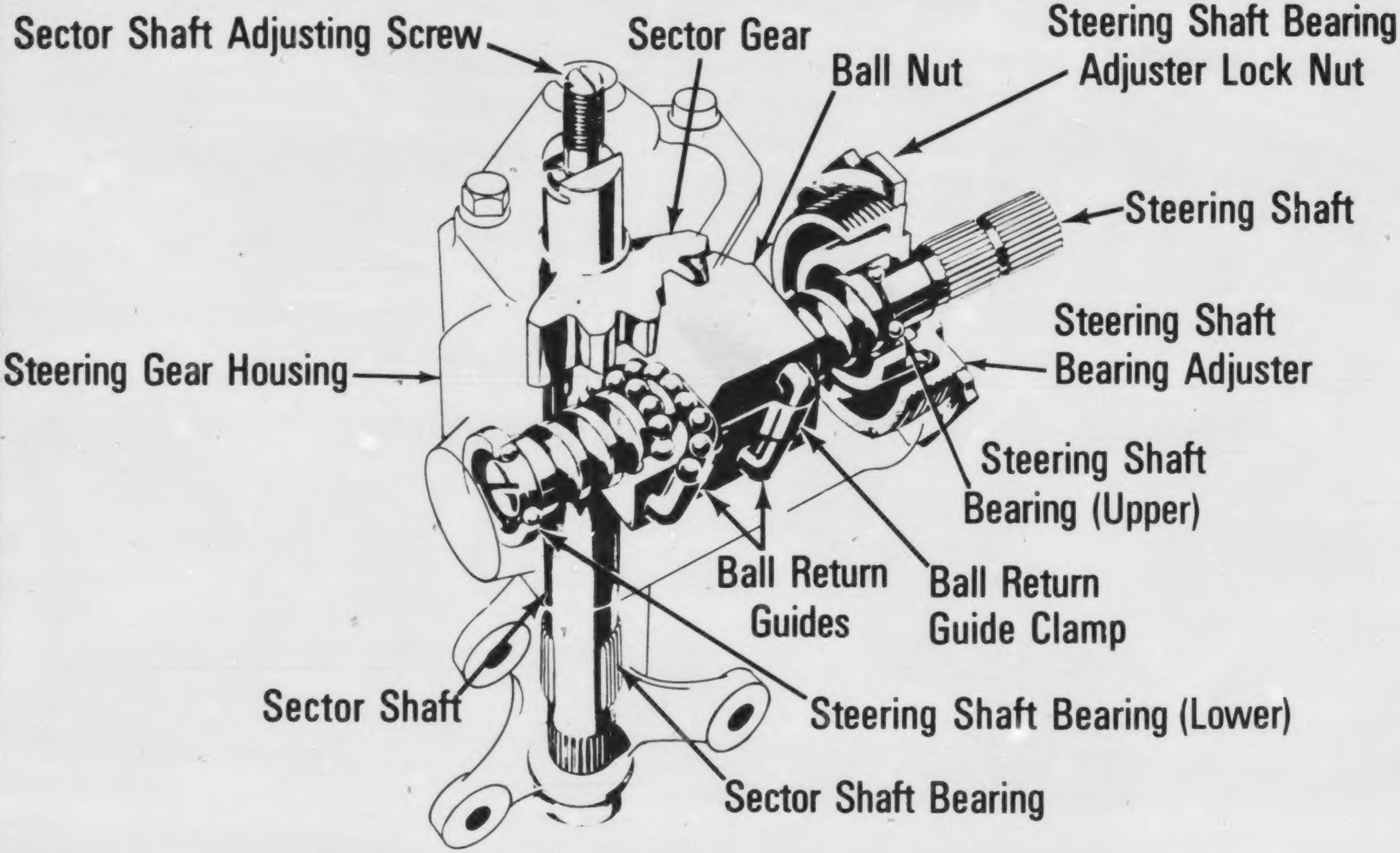
Recirculating Ball Nut and Worm


Sector Gear
Worm Gear
Recirculating Ball Nut

Rack and Pinion

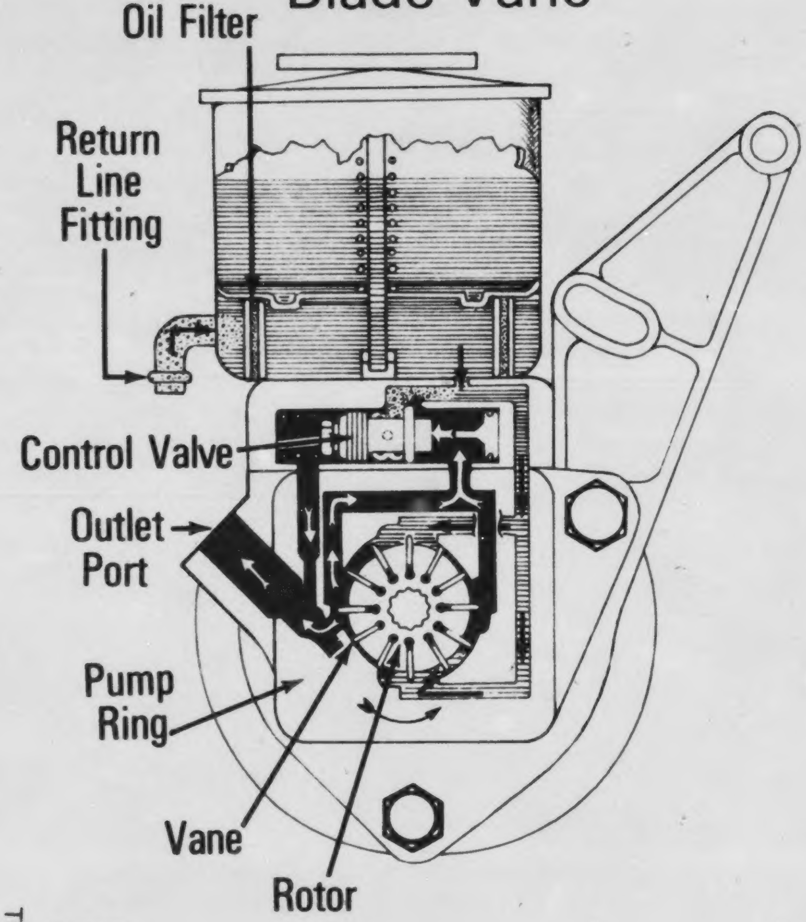

Rack Gear
Pinion Gear

Parts of a Recirculating Ball Nut and Worm

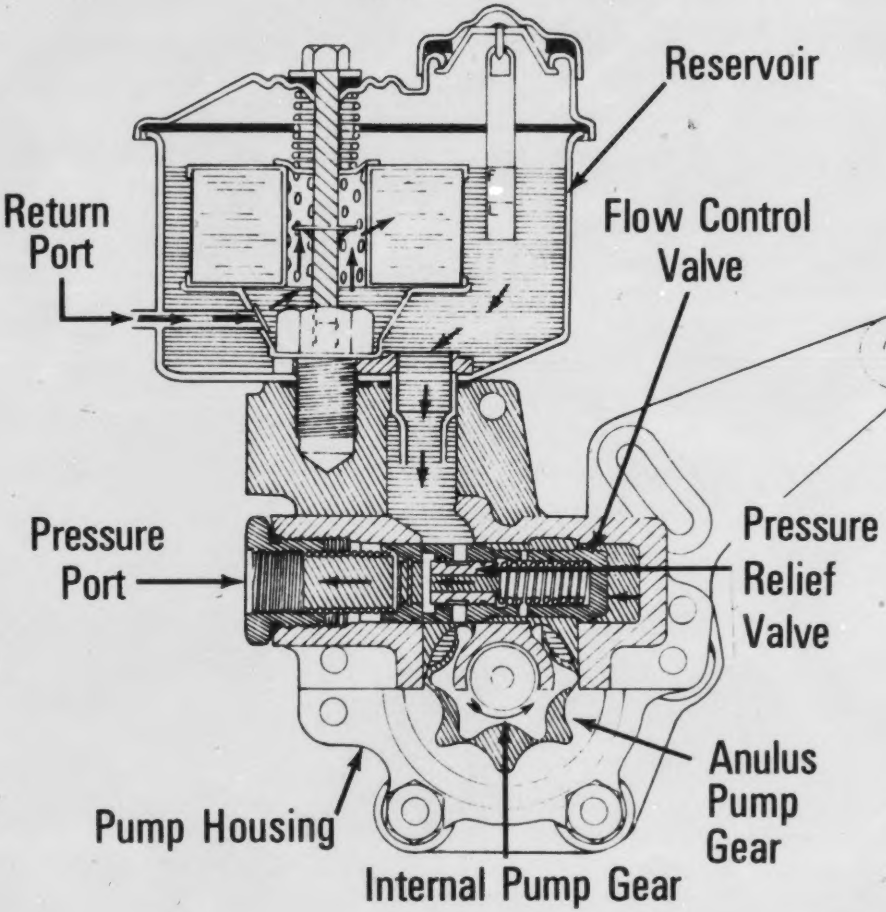

Sector Shaft Adjusting Screw
Sector Gear
Ball Nut
Steering Shaft Bearing Adjuster Lock Nut
Steering Shaft
Steering Shaft Bearing Adjuster
Steering Gear Housing
Steering Shaft Bearing (Upper)
Ball Return Guides
Ball Return Guide Clamp
Sector Shaft
Steering Shaft Bearing (Lower)
Sector Shaft Bearing

Types of Power Steering Pumps

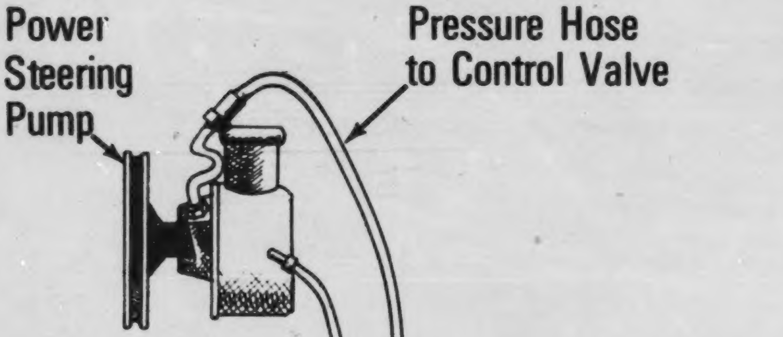
Blade Vane


Oil Filter
Return Line Fitting
Control Valve
Outlet Port
Pump Ring
Vane
Rotor

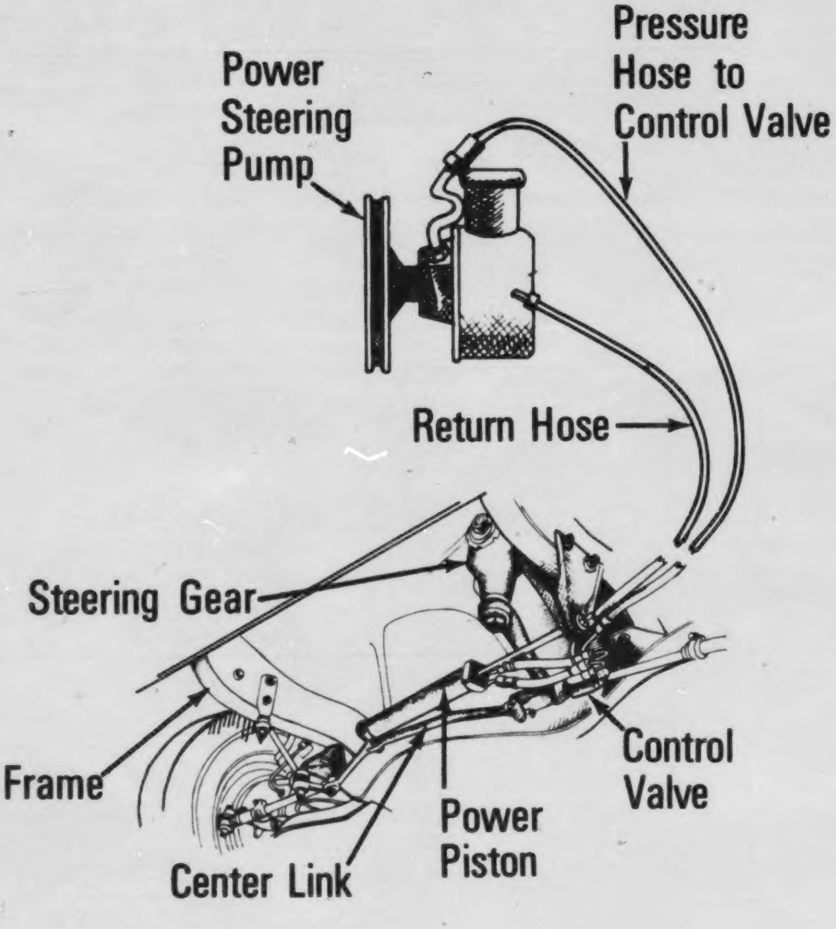
Rotary Gear


Reservoir
Return Port
Flow Control Valve
Pressure Port
Pressure Relief Valve
Anulus Pump Gear
Pump Housing
Internal Pump Gear

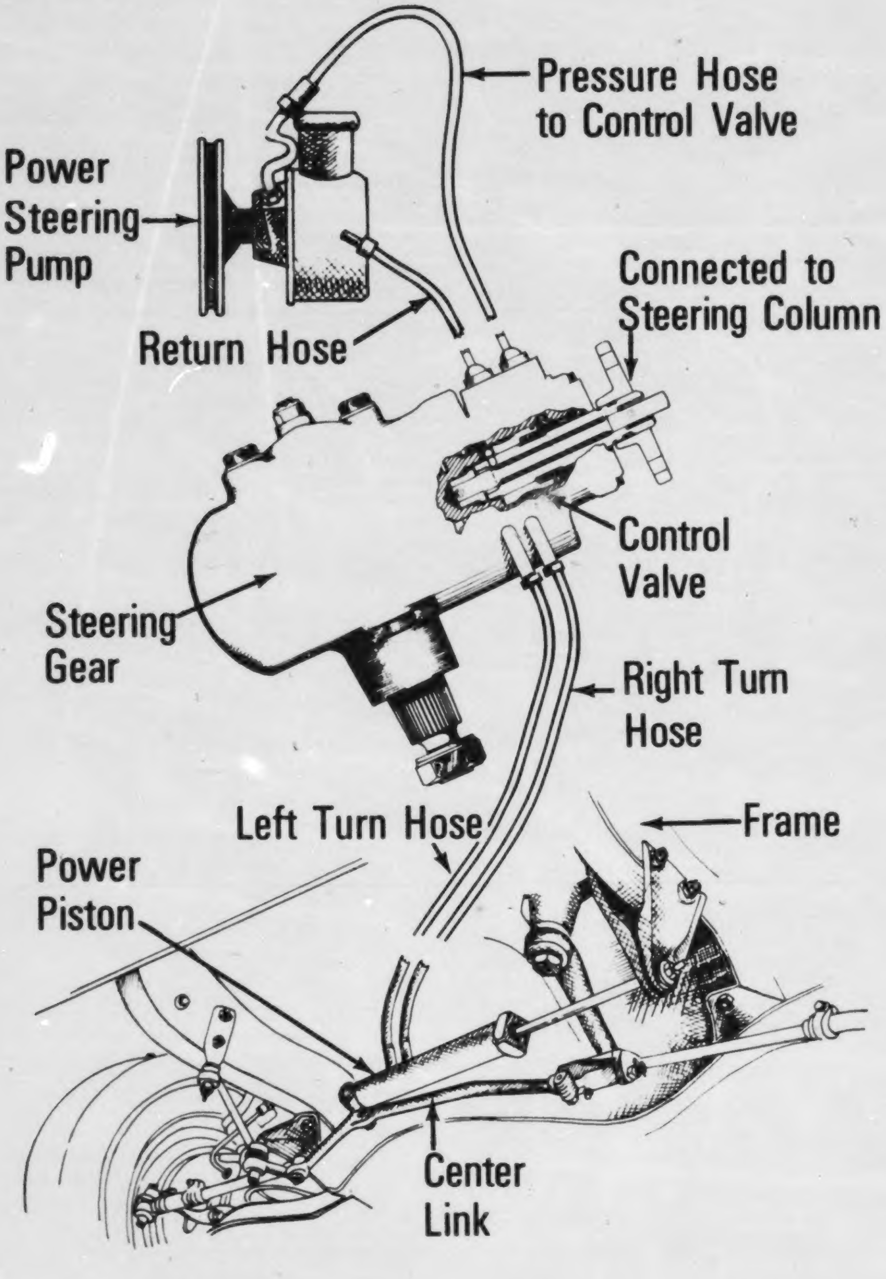
Integral Power Steering System


Power Steering Pump
Pressure Hose to Control Valve
Return Hose
Connected to Steering Column
Control Valve
Power Piston

Linkage-Booster Power Steering System


Power Steering Pump
Pressure Hose to Control Valve
Return Hose
Steering Gear
Frame
Control Valve
Power Piston
Center Link

Semi-Integral Power Steering System


Pressure Hose to Control Valve
Power Steering Pump
Connected to Steering Column
Return Hose
Control Valve
Steering Gear
Right Turn Hose
Frame
Left Turn Hose
Power Piston
Center Link

STEERING SYSTEM
UNIT V

JOB SHEET #1--INSPECT A STEERING SYSTEM FOR DAMAGED PARTS OR WEAR

I. Tools and equipment

   A. Floor jack

   B. Jack stands

   C. Suitable alignment equipment

   D. Dial indicator

II. Procedure

   A. Inspect steering gear and column adjustment for smooth operation

      1. Check steering column mounts for looseness

      2. Check steering column alignment with steering gear

      3. Check slack in steering shaft coupling, if so equipped, by twisting the steering shaft on each side of the coupling in opposite directions; watch for slack

      4. Raise the front of the vehicle and support on jack stands close to the outer ends of the lower control arms

         (NOTE: It is important to keep the steering linkage in its normal angles while checking.)

      5. Check steering gear mounting bolts for looseness

      6. Check pitman arm and retaining nut for looseness

      7. Turn the steering wheel from one stop to the other stop while examining for roughness or catches

         (NOTE: On power steering models, have the engine running while turning the wheel or checking for slack.)

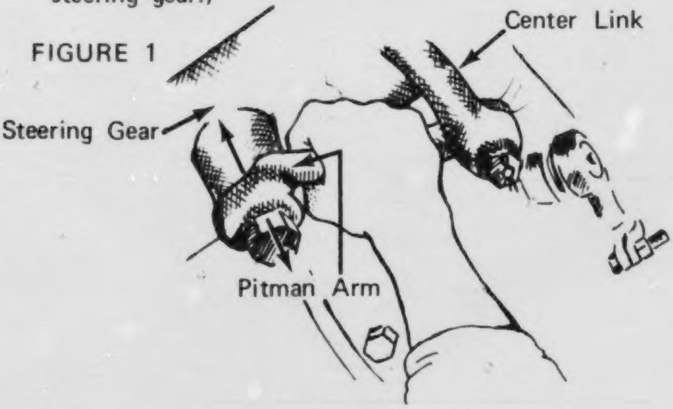
      8. Set the steering gear to over center high point by counting the number of turns from one stop to the other stop; turn the steering wheel back one-half the number of turns

JOB SHEET #1

9. Push up and pull down on the sector shaft; check for any slack in the sector gear lash (Figure 1)

   (NOTE: Any indication of slack will require readjustment of the steering gear.)

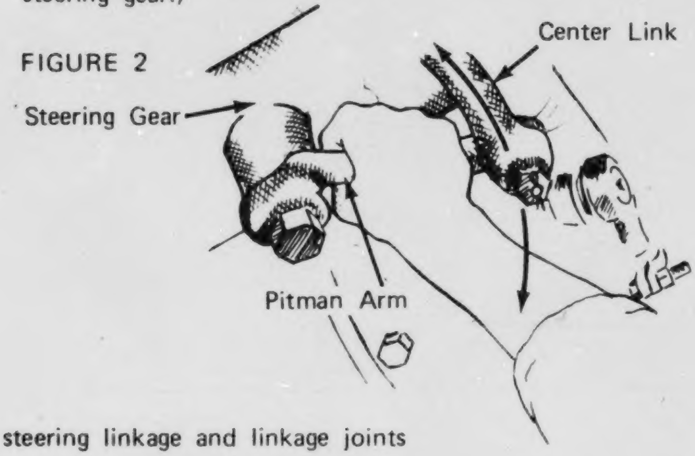
FIGURE 1



10. Pull and push horizontally on the pitman arm and feel for slack in the worm bearings (Figure 2)

    (NOTE: Any indication of slack will require readjustment of the steering gear.)

FIGURE 2



B. Inspect steering linkage and linkage joints

1. Examine tie rod ends for damaged rubber seals; replace if the seals will not repell water

2. Look for any bent linkage or loose attaching bolts

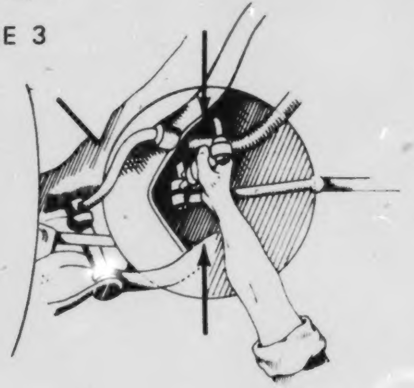
   (NOTE: Do not attempt to straighten steering parts. They are forged metal and straightening will seriously weaken them.)

   (CAUTION: All castellated nuts must be cotter pinned.)

JOB SHEET #1

3. Check the idler arm by shaking it vertically as hard as you can (Figure 3)

FIGURE 3

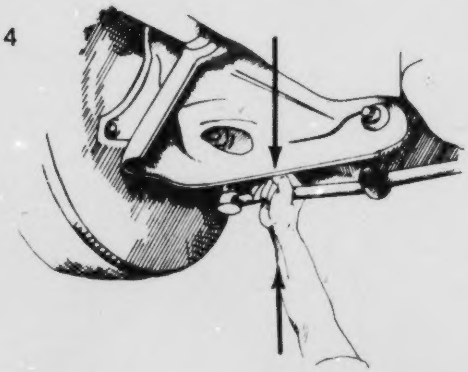


(NOTE: Any excessive vertical looseness will produce tire wear, road wander, and erratic steering. Replace the idler arm if excessive vertical looseness is found. See Figure 3.)

4. Check tie rod ends by grasping each tie rod end firmly and shaking with a vertical push-pull movement (Figure 4)

(NOTE: Tie rod ends should be replaced if any push-pull looseness is observed.)

FIGURE 4



C. Check condition of steering arms

1. Make a preliminary check of steering arms

   a. Measure the distance from the right steering arm to the right wheel rim

   b. Measure the distance from the left steering arm to the left wheel rim

   c. Compare the measurements

   (NOTE: The measurements should be equal within ± 1/8".)

JOB SHEET #1

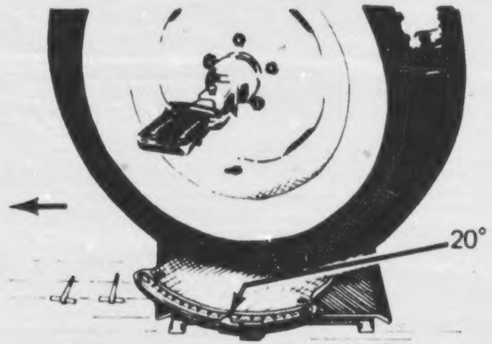
2. Measure the turning radius angles, toe-out on turns, for a more accurate check if necessary

   a. Place the front wheels on alignment turntables in a straightforward position

   b. Set the radius gauges to zero

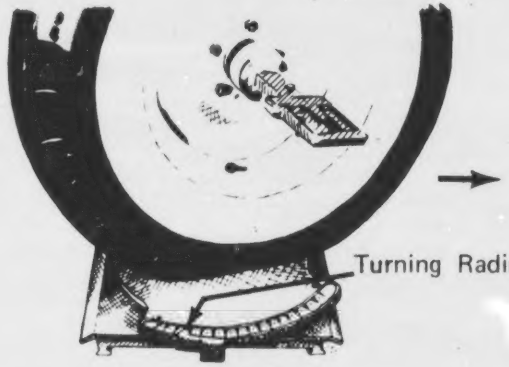
   c. Turn the left front wheel 20° towards center of the vehicle (Figure 5)

FIGURE 5



   d. Read the right turning radius gauge scale; record reading (Figure 6)

FIGURE 6



   e. Turn the right front wheel 20° towards center of vehicle

   f. Read the left turning radius gauge scale; record reading

   g. Compare readings with manufacturer's specifications

   h. Replace the steering arm that is not within the specified limits

JOB SHEET #1

D. Check steering knuckle and spindle for bent condition

(NOTE: The steering axis inclination angle will indicate a bent condition in the steering knuckle and spindle assembly.)

1. Place the front wheels on alignment turntables in a straightforward position
2. Set the turning radius scales so that the gauge pointer reads zero
3. Install caster-camber gauges

   (NOTE: A spindle mounted gauge is more accurate than a rim mounted gauge for this reading because wheels tend to roll even though the brakes are locked.)
4. Turn the left front wheel towards center of vehicle until turning radius scale reads 20°
5. Adjust steering axis inclination gauge to zero
6. Turn the wheel out from center of the vehicle until the turning radius scale reads 20°, a total of 40° swing of the wheel
7. Read steering axis inclination on the gauge; record reading
8. Turn the right front wheel towards center of the vehicle until turning radius scale reads 20°
9. Adjust steering axis inclination gauge until it reads zero
10. Turn the wheel out from center of the vehicle until the turning radius scale reads 20°, a total of 40° swing of the wheel
11. Read steering axis inclination on the gauge; record reading
12. Adjust steering axis inclination readings
    a. Add the camber reading to steering axis inclination reading if camber is positive

       Example: Manufacturer's specifications were 6° at 0° camber; your readings were 5 1/2° at 1/2° positive camber; actual steering axis inclination reading is 6°

JOB SHEET #1

b. Subtract the camber reading from steering axis inclination reading if camber is negative

Example: Manufacturer's specifications were 6° at 0° camber; your readings were 5° at 3/4° negative camber; actual steering axis inclination reading is 4 1/4°

(NOTE: Some manufacturers do not specify a steering axis inclination angle. On these models watch for an extreme camber reading, such as 2° to 3° above or below specifications, where no suspension wear is evident.)

STEERING SYSTEM
UNIT V

JOB SHEET #2--REMOVE AND REPLACE A TIE ROD END

I. Tools and equipment

- A. Floor jack
- B. Jack stands
- C. Combination wrenches, 1/2" - 3/4" (12 mm - 19 mm)
- D. Ratchet, 3/8" drive
- E. Sockets, 1/2" - 3/4" (12 mm - 19 mm)
- F. Diagonal cutter pliers
- G. Tie rod fork
- H. Ball peen hammer
- I. Penetrating oil
- J. Wire brush

II. Procedure

- A. Raise the vehicle and place on jack stands
- B. Clean the threads on the tie rod being replaced
- C. Count the threads on the tie rod end that remain out of the adjuster sleeve, record for replacement
- D. Soak the threads with penetrating oil
- E. Loosen the sleeve clamp bolt
- F. Remove cotter pin from ball stud
- G. Remove ball stud nut
- H. Break the joint between ball stud and steering arm eye with the tie rod fork and hammer
- I. Unscrew tie rod end from the adjuster sleeve
- J. Screw the new tie rod end into the adjuster sleeve until the same amount of threads are showing as recorded earlier

JOB SHEET #2

K. Place the ball stud in the steering arm eye

L. Install nut on ball stud and torque

M. Install a new cotter pin in the ball stud

N. Tighten the adjuster sleeve clamp bolt

O. Lower the vehicle

P. Check toe-in

STEERING SYSTEM
UNIT V

JOB SHEET #3--PRESSURE TEST A POWER STEERING SYSTEM

I. Tools and equipment

A. Test gauge with shutoff valve

B. Power steering pressure hose

C. Power steering fluid

D. Fender cover

E. Combination wrenches, 1/2" - 3/4" (12 mm - 19 mm)

F. Thermometer, 0° - 250°F (-18° - 125°C)

G. Drain pan

II. Procedure

A. Raise the hood

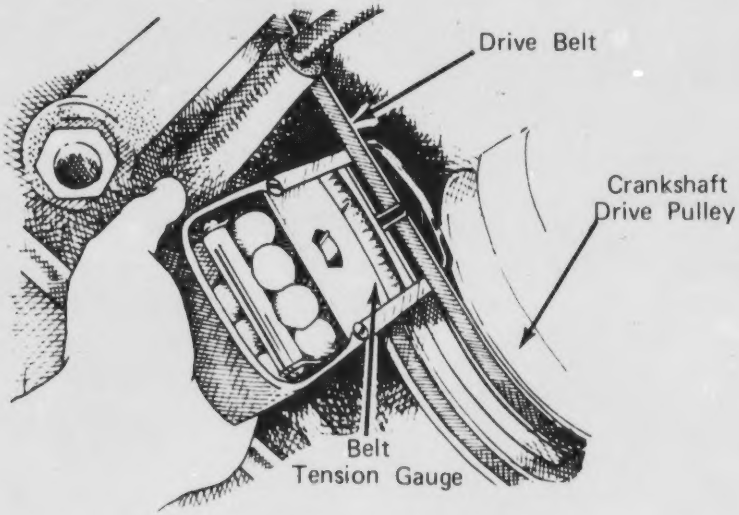
B. Place a fender cover on the left fender

C. Place a drain pan under the power steering pump area to catch fluid spilled while connecting gauges

D. Check power steering pump drive belt tension (Figure 1)

(CAUTION: Do not pry against the pump reservoir when adjusting belt tension.)

FIGURE 1



JOB SHEET #3

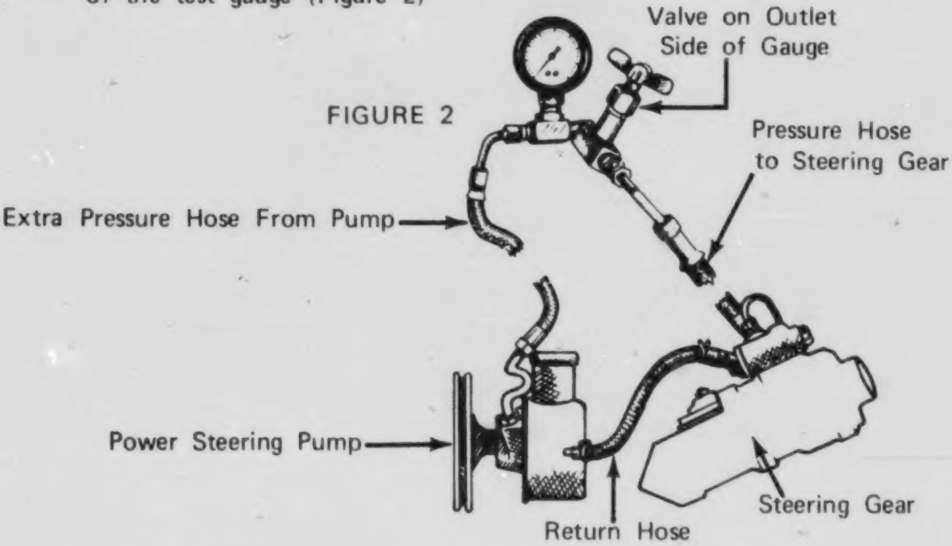
E. Disconnect the pressure hose from the power steering pump

(CAUTION: The engine should not be running.)

F. Attach an extra pressure hose to the pump and to the gauge side of the test gauge

G. Connect the pressure hose from the power steering gear to the valve side of the test gauge (Figure 2)

FIGURE 2


Valve on Outlet Side of Gauge
Pressure Hose to Steering Gear
Extra Pressure Hose From Pump
Power Steering Pump
Steering Gear
Return Hose

H. Add fluid as required to maintain a full pump reservoir

I. Start the engine with the test valve open

J. Place the thermometer in the reservoir fill tube

K. Operate the engine and power steering until the fluid temperature is 150°-170°F (66°-77°C)

L. Record the pressure at curb idle speed and open valve

M. Close the valve and take a pressure reading

(CAUTION: Leave the valve closed not more than five seconds to protect the pump from damage.)

N. Compare the reading with specifications for the pump; repair the pump if readings are 100 psi (7 kg/cm^2) or lower than specifications

JOB SHEET #3

O. Hold the steering wheel against each stop just long enough to obtain the pressure reading; record it

(NOTE: These pressures should be within 50 psi (3.5 kg/cm^2) of each other and within 50 psi (3.5 kg/cm^2) of specifications. If these pressures are off, it will be necessary to make internal repairs on the steering gear.)

P. Remove the test gauge

Q. Make the necessary repairs

STEERING SYSTEM
UNIT V

JOB SHEET #4--REMOVE, RESEAL, AND REPLACE A POWER STEERING PUMP

I. Tools and equipment

A. Fender cover

B. Power steering fluid

C. Combination wrench set, 3/8" - 1" (8 mm - 25 mm)

D. Plastic tip hammer

E. Shaft seal puller

F. Shaft seal driver

G. Shaft seal protector

H. Drive pulley puller

I. Standard screwdriver, medium blade

J. Block of wood, 2" x 2" x 6" (5 cm x 5 cm x 15 cm)

K. Drain pan

II. Procedure

A. Raise the hood

B. Place a fender cover on the left front fender

C. Remove the power steering hoses at the pump

(NOTE: Use the drain pan to catch the fluid from the pump.)

D. Plug the hose ends to prevent foreign material from entering the system

E. Remove drive belt

F. Remove mounting bolts from pump

G. Remove the power steering pump

(NOTE: Be sure to empty the remaining fluid from the pump.)

JOB SHEET #4

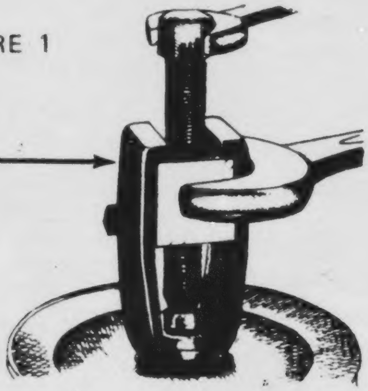
H. Remove any support parts remaining on the pump

I. Remove the drive pulley retaining nut if so equipped

J. Remove pulley with a puller on pulley hub

(CAUTION: Do not hammer or pry on pulley.)

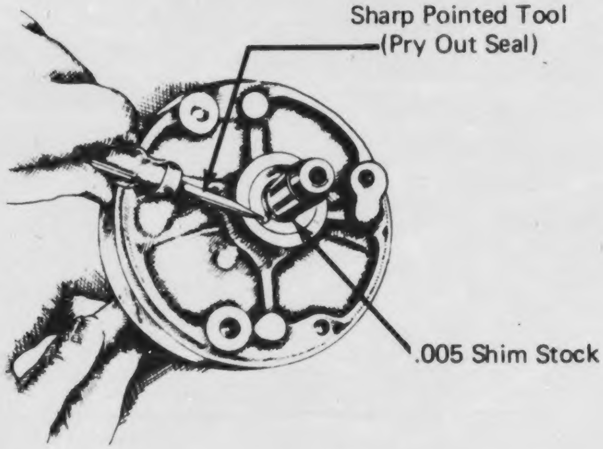
FIGURE 1


Special
Puller

K. Remove the shaft seal with a seal puller

(NOTE: If a puller is not available, wrap the shaft with shimstock for protection. Pierce the seal with a sharp punch and then pry it out. See Figure 2.)

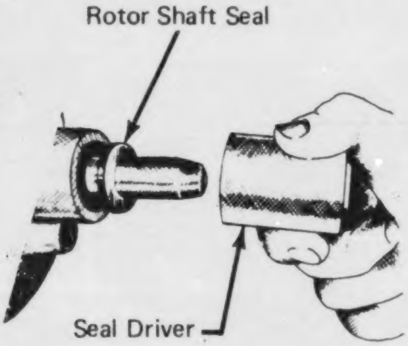
FIGURE 2


Sharp Pointed Tool
(Pry Out Seal)
.005 Shim Stock

JOB SHEET #4

L. Replace the seal and drive it squarely into the seal seat with a driver (Figure 3)

FIGURE 3



M. Remove the reservoir retaining bolts and fluid outlet union

N. Remove the reservoir by tapping lightly on the rim

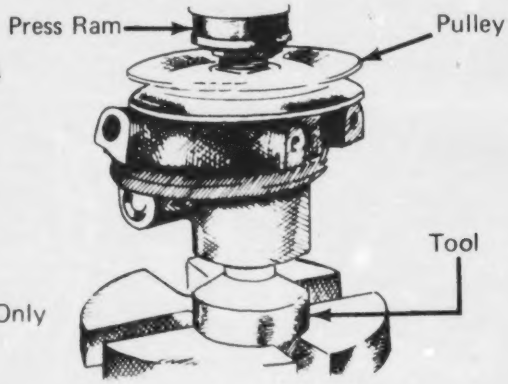
O. Wash the reservoir in solvent and air dry

P. Remove the old "O" ring seals from the pump body

(NOTE: Replace the press-on type drive pulley before installing the reservoir.)

(CAUTION: Support the bottom of the shaft while pressing the pulley on. See Figure 4.)

FIGURE 4



Press on the Shaft Only

JOB SHEET #4

Q. Install new seals into clean seal recesses in the pump body

R. Lubricate the reservoir seal surface with power steering fluid

S. Place the reservoir on the pump body with the holes in the reservoir aligned with the pump holes

T. Lay the small wooden block across the reservoir; tap the reservoir in place

(CAUTION: Protect the pump shaft from sharp blows or heavy axial force.)

U. Replace and torque the retainer bolts and fluid union

V. Replace the drive pulley and torque the retainer nut if so equipped

W. Replace any pump mounts or accessories removed earlier

X. Install the pump on the vehicle

Y. Place drive belt on the pulley

Z. Tighten the belt to specified tension

(CAUTION: Do not move the pump by prying on the reservoir or pulling on the filler neck.)

AA. Reconnect the hoses

(NOTE: Align the hoses as they are tightened so they will not be damaged during operation.)

BB. Fill the pump reservoir with power steering fluid

CC. Bleed the air from the system by starting the engine and stopping it after a few seconds, adding fluid as needed; repeat three or four times

DD. Start the engine; turn the steering wheel to each side stop and hold for two seconds

EE. Check fluid level

FF. Recheck for any fluid leaks

GG. Road test with the instructor

HH. Recheck for fluid leaks

STEERING SYSTEM
UNIT V

JOB SHEET #5--REMOVE, RECONDITION, AND REPLACE A RECIRCULATING BALL TYPE STEERING GEAR

I. Tools and equipment

   A. Floor jack

   B. Jack stands

   C. Puller for pitman arm

   D. Socket, 1/2" drive, 1 1/4" (32 mm)

   E. Breakover handle, 1/2" drive

   F. Pin punch, 1/4" (6 mm)

   G. Ball peen hammer

   H. Combination wrench set, 3/8" - 1" (8 mm - 25 mm)

   I. Ratchet, 3/8" drive

   J. Sockets, 3/8" drive, 3/8" - 3/4" (8 mm - 19 mm)

   K. Standard screwdriver, thin blade

   L. Standard screwdriver, medium blade

   M. Drift punch, 3/8" x 12" (.8 cm x 30 cm)

   N. Torque wrench, inch pound

   O. Torque wrench, foot pound

   P. Torque wrench adaptor for steering shaft

   Q. Parts pan

II. Procedure

   A. Raise the vehicle and place on jack stands

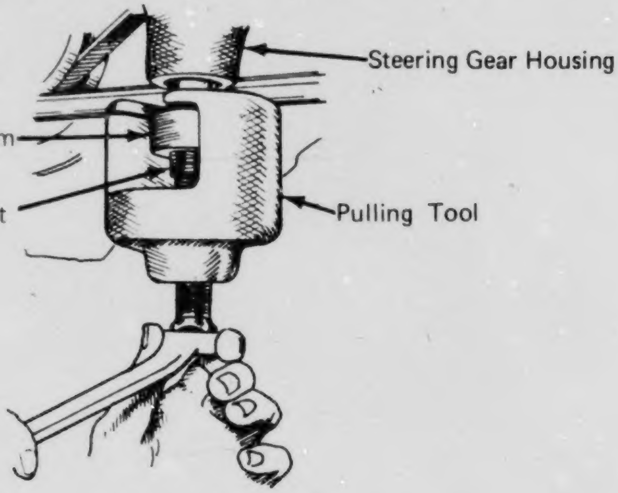
   B. Center the steering gear and mark the relationship of the pitman arm to the cross shaft

   C. Remove the pitman arm nut and lock washer

JOB SHEET #5

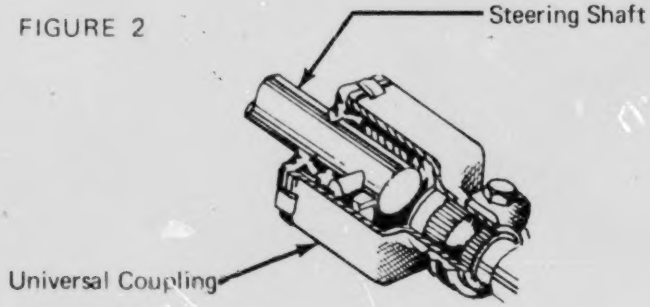
D. Pull the pitman arm with a suitable puller (Figure 1)

FIGURE 1


Steering Gear Housing
Pitman Arm
Sector Shaft
Pulling Tool

E. Disconnect the steering shaft coupling (Figure 2)

FIGURE 2


Steering Shaft
Universal Coupling

(NOTE: Some models will not have a coupling; so the steering column will be removed with the gears.)

F. Remove the steering gear housing attaching bolts

G. Remove the steering gear assembly

(NOTE: On some models it may be necessary to remove other items such as exhaust manifold, exhaust pipe, and other vehicle accessories to allow steering gear removal.)

H. Clean the outside of the gear housing and clamp it in a vise on one of the mount bolt areas

JOB SHEET #5

I. Center the gear by turning it from one side to the other while counting the turns; then turn it back one-half the number of turns

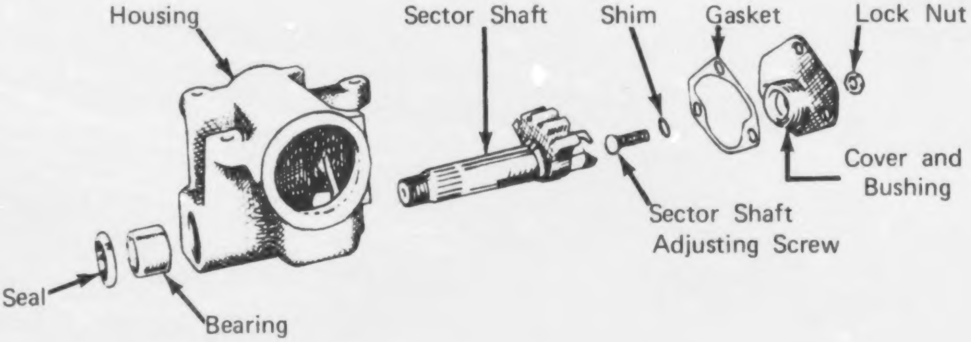
J. Remove sector adjusting screw lock nut

(NOTE: See Figure 3.)

K. Remove side cover bolts

L. Remove side cover by screwing the sector adjusting screw through the side cover with a thin blade screwdriver (Figure 3)

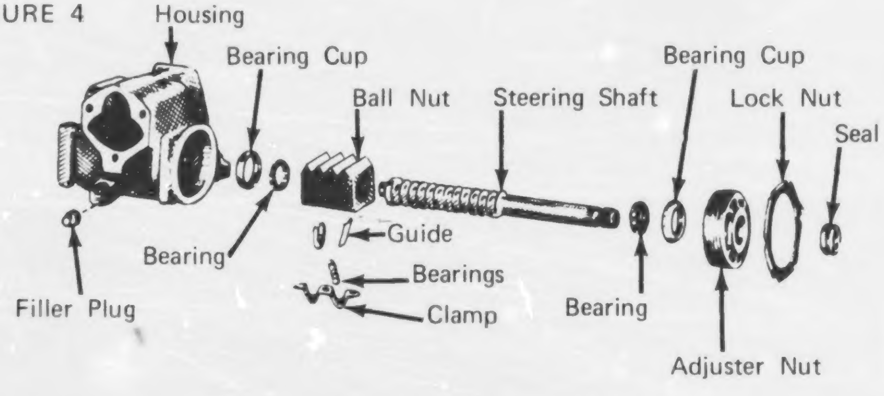
FIGURE 3


Housing
Sector Shaft
Shim
Gasket
Lock Nut
Cover and Bushing
Sector Shaft Adjusting Screw
Seal
Bearing

M. Remove the sector gear and cross shaft from the housing

N. Remove the lock nut from the worm bearing adjuster nut (Figure 4)

FIGURE 4


Housing
Bearing Cup
Ball Nut
Steering Shaft
Bearing Cup
Lock Nut
Seal
Guide
Bearings
Clamp
Bearing
Filler Plug
Bearing
Adjuster Nut

O. Remove the worm bearing adjuster assembly and steering shaft upper bearing

(NOTE: See Figure 4.)

JOB SHEET #5

P. Pull the steering shaft and ball nut from the housing carefully

Q. Remove the lower worm bearing

(NOTE: See Figure 4. Disassemble the ball nut only if there is indication of binding or tightness when operated.)

(CAUTION: To avoid possible damage to the ball return guides, keep the ball nut from running down to either end of the worm shaft.)

R. Remove the ball return guide clamp

S. Set the ball nut and steering shaft assembly in a clean parts pan

T. Remove ball guides

U. Turn the ball nut over and rotate the worm shaft from side to side until all the balls are out of the nut

V. Slide the worm shaft out of the ball nut

W. Clean all parts with solvent; air dry

X. Inspect all bearing surfaces for chipping, spauling, or discoloration, including worm shaft and ball nut; replace as necessary

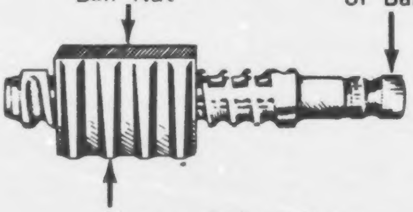
Y. Inspect the worm and cross shaft for straightness and spline condition

Z. Remove the cross shaft seal from the steering gear housing; inspect the housing for cracks or damage

AA. Replace the seals and bearings in the adjuster nut and gear housing as necessary

BB. Reassemble the ball nut and steering shaft by centering the shaft in the nut (Figure 5)

FIGURE 5



JOB SHEET #5

CC. Insert the ball guides into the holes of the ball nut and tap in lightly until they are seated

DD. Place one-half of the balls in each of the ball guides

(NOTE: It may be necessary to rotate the shaft slightly in each direction to allow the balls to distribute themselves through the circuit.)

EE. Install ball guide clamp; torque the screws

FF. Coat the threads of steering shaft adjusting nut side cover bolts and sector adjusting screw with an oil resistant sealing compound during reassembly

GG. Lubricate all bearing surfaces and seal lips during reassembly

HH. Place the lower worm bearing on the bearing cup in the gear housing

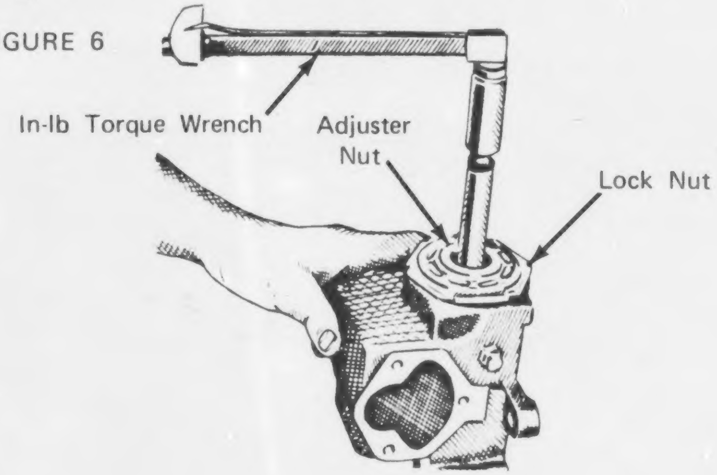
II. Insert the steering shaft assembly in the gear housing

JJ. Position the steering shaft upper bearing on the worm

KK. Install the steering shaft adjuster nut assembly

LL. Adjust the worm bearing preload using an inch pound torque wrench (Figure 6)

FIGURE 6



MM. Tighten the adjuster nut until the steering shaft rotating force is equal to the specified torque

(NOTE: See Figure 6.)

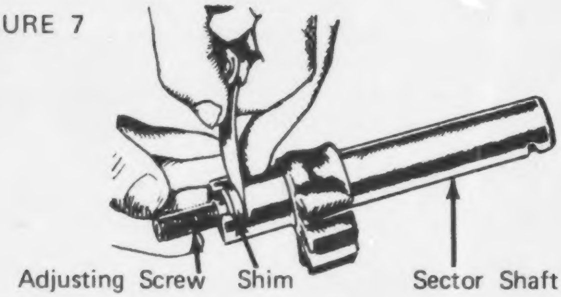
JOB SHEET #5

NN. Tighten the lock nut

OO. Place the sector lash adjusting screw and shim in the sector

PP. Check the end clearance to make sure screw is free moving but does not exceed .002" (.051 mm) clearance

FIGURE 7



(NOTE: Correct the end play by adding or subtracting to shim thickness.)

QQ. Attach the sidecover to the sector

RR. Install a new gasket on the side cover

SS. Center the ball nut in the housing opening

TT. Insert the cross shaft in the housing while aligning the center sector gear tooth with the center of the ball nut

UU. Turn the side cover out of the way; fill the gear housing with the specified amount of lubricant

VV. Realign side cover with housing; start the bolts

(CAUTION: Do not tighten cover bolts until it is certain there is some lash between the ball nut and sector gear.)

WW. Torque the side cover bolts

XX. Reset the steering gear to the over center high point

JOB SHEET #5

YY. Adjust the sector lash adjusting screw until an additional specified torque is required to turn the steering shaft and worm assembly through over center high point (Figures 8 and 9)

FIGURE 8

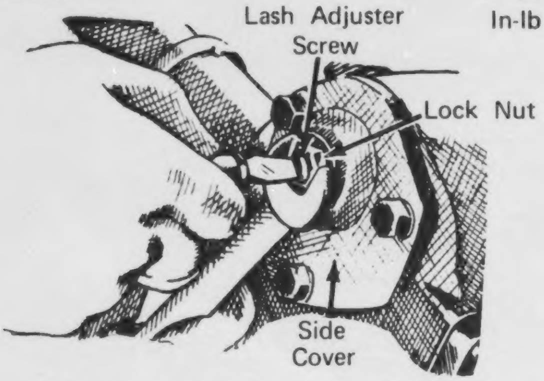
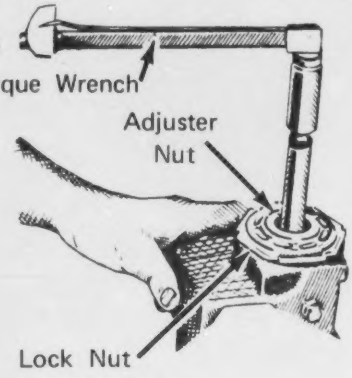


FIGURE 9



ZZ. Hold the sector lash adjusting screw while tightening the lock nut

AAA. Rotate the steering shaft from one stop to the other end feel for a slightly tighter turn effort through over center high point

BBB. Reinstall steering gear assembly on vehicle frame

CCC. Set steering gear to over center high point again

DDD. Attach the steering shaft coupling with the steering wheel in its centered position

EEE. Align the reference mark on the pitman arm and cross shaft as the pitman arm is attached; torque the retaining nut

FFF. Replace any item that was removed to allow steering gear removal

GGG. Lower vehicle to the floor

HHH. Road test with instructor

STEERING SYSTEM
UNIT V

TEST

1. Write the purposes of the steering system.

2. Match the terms on the right to the correct definition. (Definitions are continued on the next page.)

_____a. Mechanical steering system that provides a hydraulic power assist unit to reduce the driver turning effort

_____b. Steering column that allows the driver to change the vertical angle of the steering wheel

_____c. Steering gear that has a high ratio at center high point; the ratio decreases as the gear is turned in either direction

_____d. Steering column that allows the distance between the steering wheel and the driver to be adjusted

_____e. Bending the outer ends of the steering arms slightly inward so that when the vehicle is making a turn the inside wheel will turn more sharply than the outer wheel; produces toe-out on turns

_____f. Provides a positive lock on transmission gear selector as well as steering system

_____g. Steering gear with a fixed gear ratio throughout the total gear travel

_____h. Steering column that will collapse on impact to lessen the possibility of injury to the driver in an accident

1. Parallelogram steering linkage
2. Ackerman principle
3. Energy-absorbing steering column
4. Power steering
5. Constant ratio power steering
6. Telescopic steering column
7. Over center high point
8. Function-locking or anti-theft steering column
9. Tilt wheel steering column
10. Variable ratio power steering

______i. Steering system utilizing two short tie rods connected to the steering arms and to a long center link; one end of the link is supported by an idler arm and the other end is attached to the pitman arm to form a parallelogram shape

______j. Worm and sector gears are designed so that at the center of their travel the gear tooth mesh is at its closest tolerance

3. Identify the parts of the steering system illustrated below by placing the correct numbers in the blanks provided.

______a. Steering spindle bolt

______b. Steering column

______c. Steering gear

______d. Center link or relay link

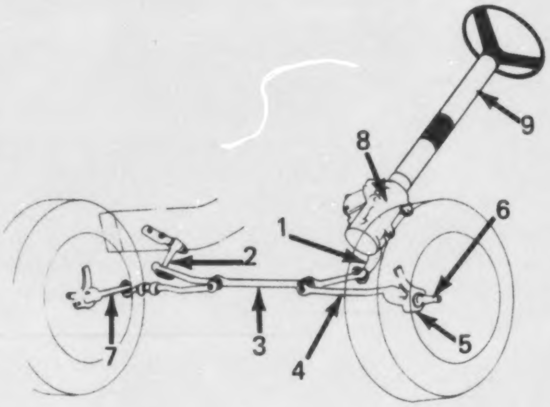
______e. Idler arm

______f. Tie rod

______g. Pitman arm

______h. Steering knuckle

______i. Steering arm



4. Name five steering parts which should be inspected for wear, adjustment, and damage.

a.

b.

c.

d.

e.

5. List three types of manual steering gears.

a.

b.

c.

6. Identify the parts of the recirculating ball nut and worm manual steering gear in the diagram below by placing the correct number in the blank provided.

______a. Steering shaft

______b. Steering shaft bearing adjuster

______c. Ball nut

______d. Sector gear

______e. Sector shaft adjusting screw

______f. Sector shaft

______g. Steering gear housing

______h. Ball return guide

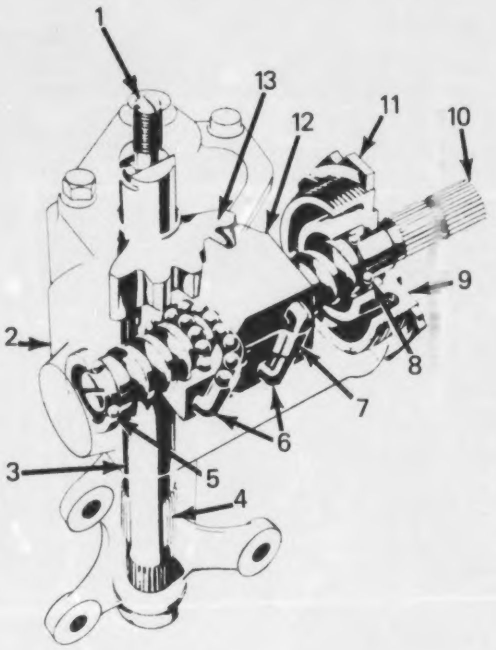
______i. Steering shaft bearing (lower)

______j. Sector shaft bearing

______k. Steering shaft bearing adjuster lock nut

______l. Ball return guide clamp

______m. Steering shaft bearing (upper)



7. List two types of power steering pumps.

a.

b.

8. Describe the three types of power steering systems.

a. Integral

b. Linkage-booster

c. Semi-integral

9. Demonstrate the ability to:

    a. Inspect a steering system for damaged parts or wear.

    b. Remove and replace a tie rod end.

    c. Pressure test a power steering system.

    d. Remove, reseal, and replace a power steering pump.

    e. Remove, recondition, and replace a recirculating ball type steering gear.

    (NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

STEERING SYSTEM
UNIT V

ANSWERS TO TEST

1. a. To turn the front wheels of the vehicle right or left with minimum effort
   b. To maintain directional control
2. a. 4
   b. 9
   c. 10
   d. 6
   e. 2
   f. 8
   g. 5
   h. 3
   i. 1
   j. 7
3. a. 6
   b. 9
   c. 8
   d. 3
   e. 2
   f. 4
   g. 1
   h. 5
   i. 7
4. a. Steering gear
   b. Steering column
   c. Steering linkage
   d. Steering arm
   e. Steering knuckle

5. a. Recirculating ball nut and worm
   b. Worm and sector
   c. Rack and pinion
6. a. 10
   b. 9
   c. 12
   d. 13
   e. 1
   f. 3
   g. 2
   h. 6
   i. 5
   j. 4
   k. 11
   l. 7
   m. 8
7. a. Rotary gear
   b. Vane
8. Description should include:
   a. Integral--Power cylinder and control valve built into the gear housing
   b. Linkage-booster--Power cylinder and control valve mounted on the steering linkage
   c. Semi-integral--Power cylinder attached to the steering linkage; control valve built into the steering gear housing
9. Performance skills will be evaluated to the satisfaction of the instructor.

WHEEL ALIGNMENT
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to write the purpose of wheel alignment and match wheel alignment angles to the correct definitions and purposes. The student should be able to demonstrate the ability to make preliminary front-end checks before wheel alignment and align a front end. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Write the purpose of wheel alignment.
2. Match the wheel alignment angles to the correct definitions.
3. Match the wheel alignment angles to the correct purposes.
4. List preliminary steps to wheel alignment.
5. Demonstrate the ability to:
    a. Make preliminary checks before wheel alignment.
    b. Align a front end.

WHEEL ALIGNMENT
UNIT VI

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined in the job sheets.

   G. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Demonstrate the ability to accomplish the procedures outlined in the job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Camber

      2. TM 2--Caster

      3 TM 3--Toe-in

   4. TM 4--Toe-out on Turns
   5. TM 5--Steering Axis Inclination

D. Job sheets

   1. Job Sheet #1--Make Preliminary Checks Before Wheel Alignment
   2. Job Sheet #2--Align a Front End

E. Test

F. Answers to test

II. References:

A. Bacon, E. Miles. *Principles of Wheel Alinement Service.* New York: McGraw-Hill Book Co., 1971.

B. Sun Oil Company. *Car Service Training Guide.* Chek-chart/Division of the H. M. Gousha Co., 1970.

C. *Up Front Where the Profits Are: Selling and Servicing the Front End Market.* Moog Industries, Inc., 1964.

WHEEL ALIGNMENT
UNIT VI

INFORMATION SHEET

I. Purpose of wheel alignment--To place the wheels of a vehicle in correct relative position to enable a free-rolling movement over the road without scuffing, dragging, or slipping

II. Definitions of wheel alignment angles

   A. Camber--Inward or outward tilt of the wheel at the top (Transparency 1)

   (NOTE: Negative camber is the inward tilt; positive camber is the outward tilt.)

   B. Caster--Backward or forward tilt of the kingpin or ball joint at the top (Transparency 2)

   (NOTE: Negative caster is the forward tilt; positive caster is the backward tilt.)

   C. Toe-in--Amount that wheels are closer together at the extreme front of the tires than at the extreme rear of the tires (Transparency 3)

   D. Toe-out on turns--Angle made by the inner wheel as compared to the outer wheel when the vehicle goes into a turn (Transparency 4)

   (NOTE: The inner front wheel always turns shorter than the outer front wheel.)

   E. Steering axis inclination--Inward tilt of the kingpin or ball joint at the top as compared to true vertical (Transparency 5)

III. Purposes of wheel alignment angles

   A. Camber--To bring the road contact point of the tire more nearly under the point of load and eliminate excessive tire wear

   B. Caster--To enable the front wheels to maintain a straight-ahead position or return to a straight-ahead position after a turn has been completed

   C. Toe-in--To compensate for varying tolerances in the steering linkage and to prevent excessive tire wear

   D. Toe-out on turns--To allow the inner front wheel to roll freely on turns and prevent the outer wheel from dragging

   E. Steering axis inclination--To aid steering stability and establish a pivot point about which the wheel can be easily turned

INFORMATION SHEET

IV. Preliminary steps to wheel alignment

   A. Tire conditions

   B. Tire pressure

   C. Wheel runout

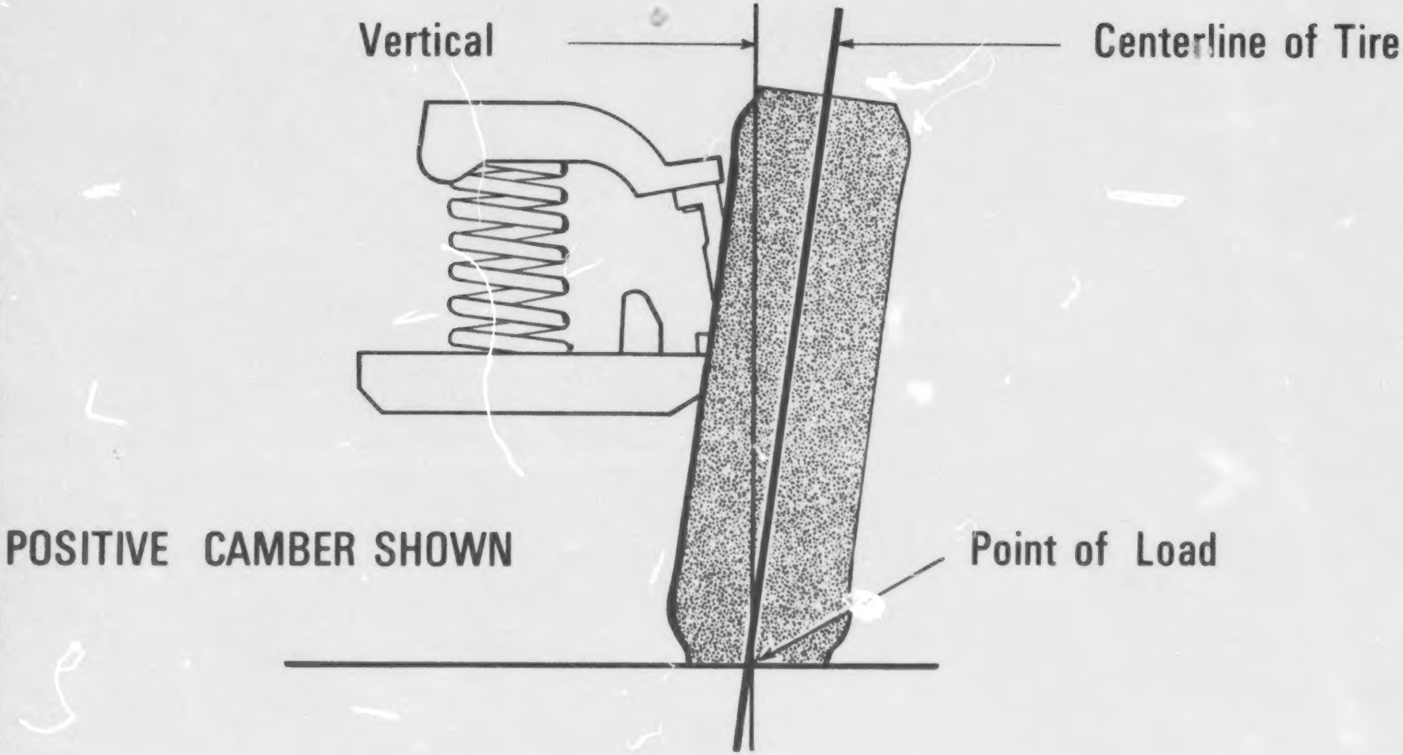
   D. Wheel bearing adjustment

   E. Front-end looseness

   F. Shock absorbers

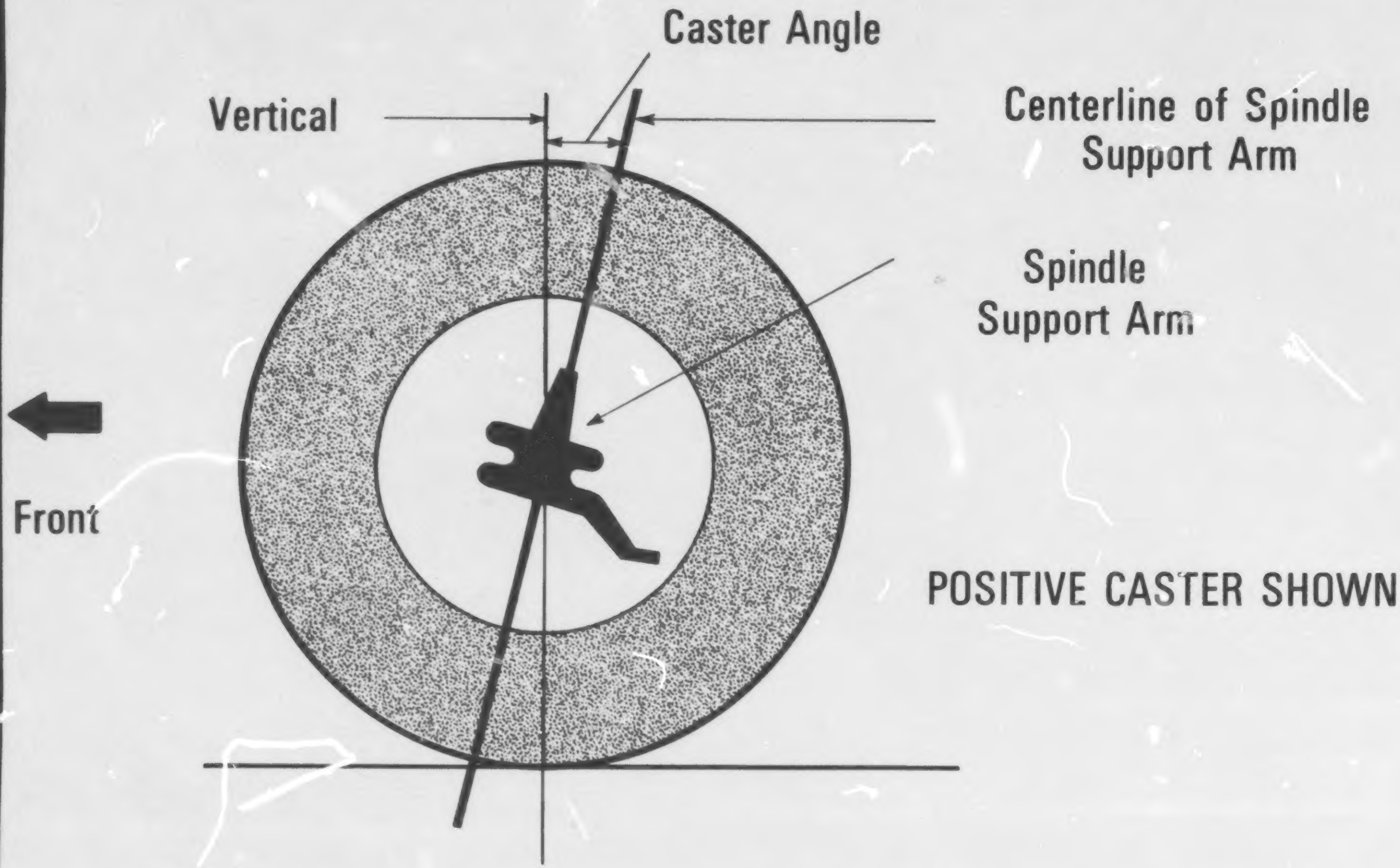
   G. Spring sag

Camber


Vertical
Centerline of Tire
POSITIVE CAMBER SHOWN
Point of Load

The outward or inward tilt of the wheel at the top.

Caster

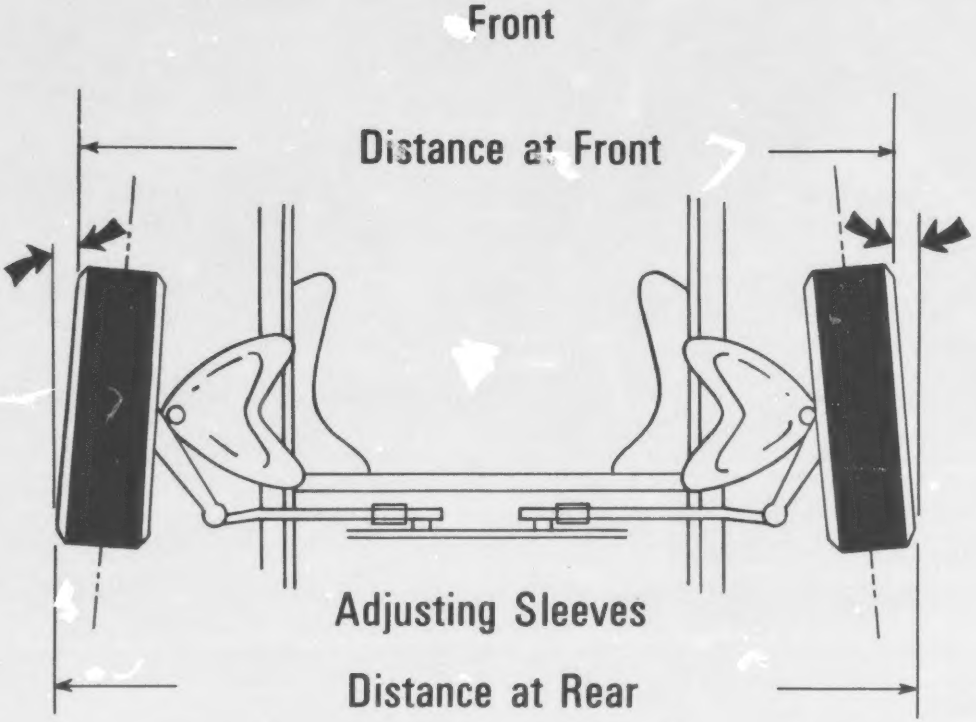

Caster Angle
Vertical
Centerline of Spindle Support Arm
Spindle Support Arm
Front

POSITIVE CASTER SHOWN

The forward or rearward tilt of the spindle support arm at the top.

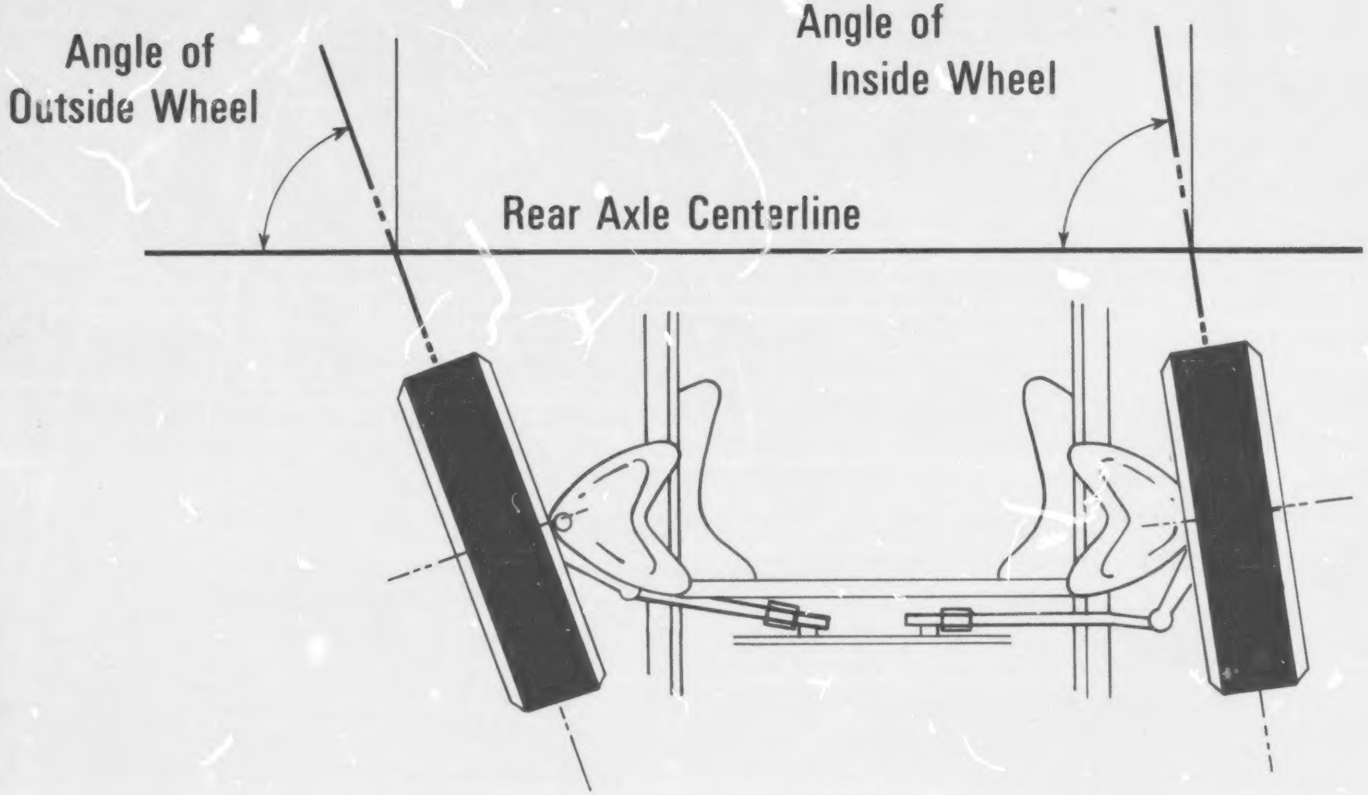
Toe-in

A shorter distance between the wheels at the front than at rear.

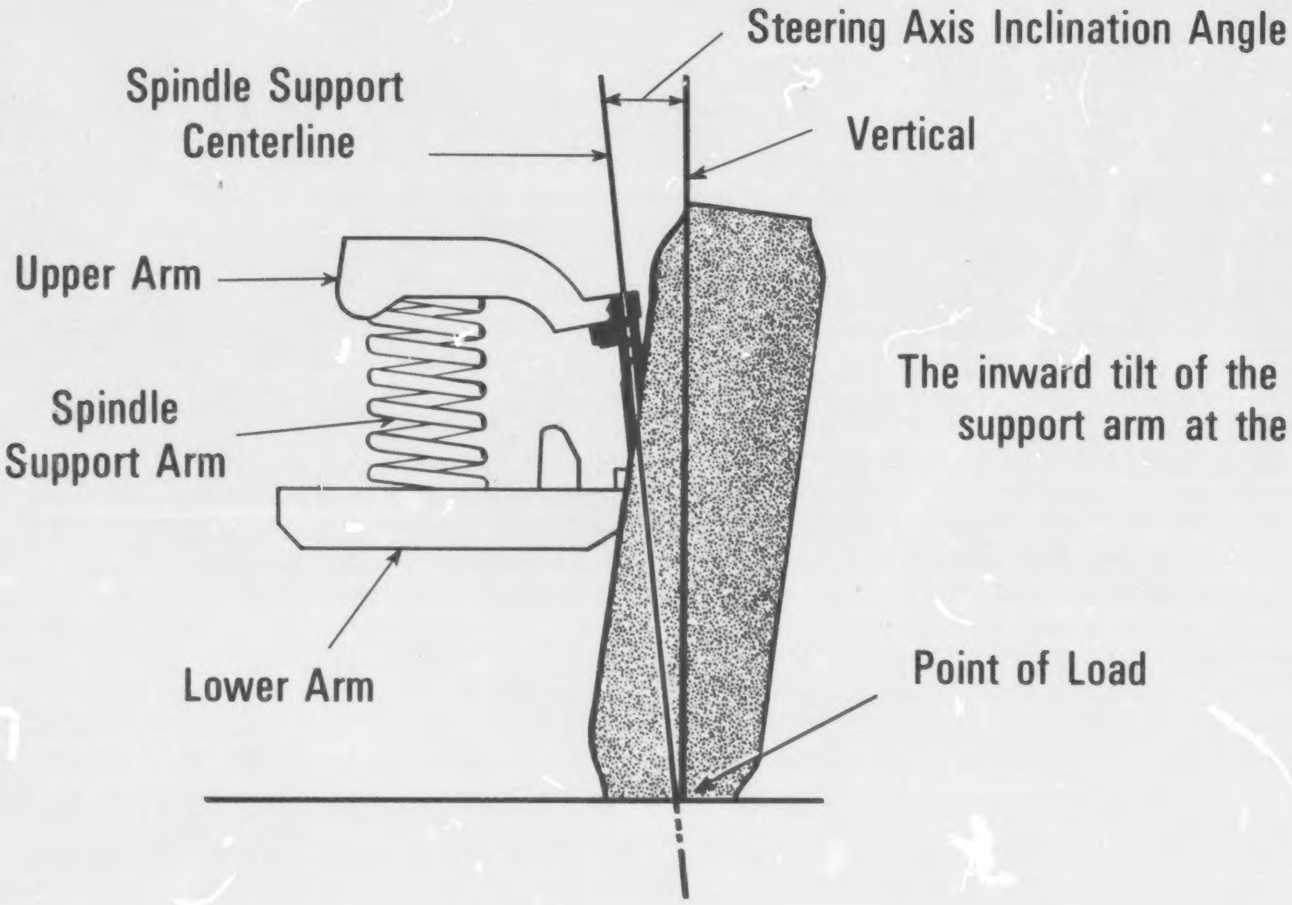

Front
Distance at Front
Adjusting Sleeves
Distance at Rear

Toe-out on Turns

The relation of one front wheel to the other on a turn.


Angle of Outside Wheel
Angle of Inside Wheel
Rear Axle Centerline

Steering Axis Inclination


Steering Axis Inclination Angle
Spindle Support Centerline
Vertical
Upper Arm
Spindle Support Arm
Lower Arm
Point of Load

The inward tilt of the spindle support arm at the top.

WHEEL ALIGNMENT
UNIT VI

JOB SHEET #1--MAKE PRELIMINARY CHECKS BEFORE WHEEL ALIGNMENT

I. Tools and equipment

A. Floor jack

B. Suitable jack stands

C. Pry bar

D. Manufacturer's specifications for front end

E. Tire gauge

F. Suitable tire spinning equipment

II. Procedure

A. Adjust vehicle to normal *curb weight* with a full tank of fuel; remove all loads except spare tire

B. Check tires for signs of wear, breaks, cuts, bruises, or any condition that will require service before alignment

C. Check tire pressure and adjust to recommended level

(NOTE: Accuracy of wheel alignment will depend upon correct tire pressure.)

D. Check shock absorber action by bouncing car at all four corners

E. Examine front springs for sagging or breakage

(NOTE: If torsion bar type, adjust to recommended height.)

F. Check front wheel bearings for looseness; adjust if necessary

G. Examine steering linkage and steering arms for looseness or deformation; replace if necessary

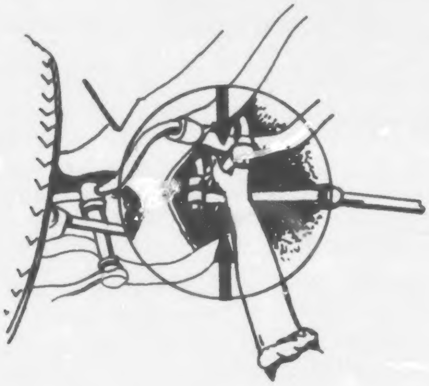
(NOTE: It is important to keep the steering linkage in its normal angles while checking for looseness.)

JOB SHEET #1

1. Grasp the idler arm firmly and shake it vertically (Figure 1)

   (NOTE: Replace the idler arm if excessive vertical looseness is found.)

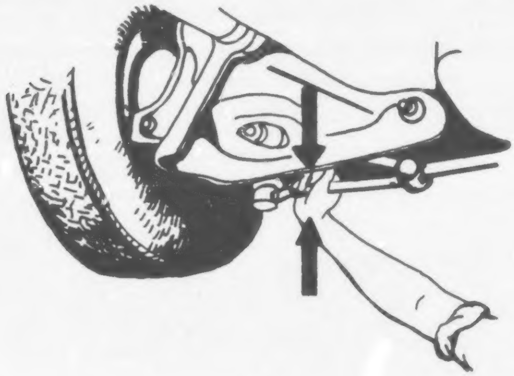
FIGURE 1



2. Grasp each tie-rod end firmly and shake with a push-pull movement (Figure 2)

   (NOTE: Replace tie-rod ends having excessive push-pull looseness.)

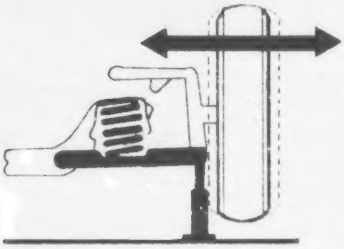
FIGURE 2



JOB SHEET #1

3. Rock the tire inward and outward with a jerk and observe any movement of the steering gear housing or slack in the steering sector and worm gears (Figure 3)

FIGURE 3

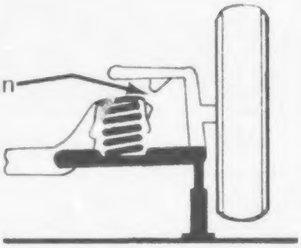


H. Inspect control arms and kingpins or ball joints for excessive looseness; adjust or replace as required

1. Unload ball joints

   a. Hoist the car at the lower control arm when the spring is supported by the lower control arm (Figure 4)

FIGURE 4



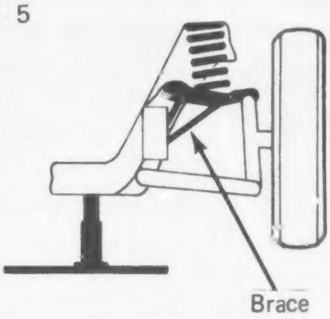
Must maintain gap here

JOB SHEET #1

b. Hoist the car at the frame when the spring is supported at the upper control arm

(NOTE: A brace should be installed between the upper control arm and frame. See Figure 5.)

FIGURE 5



2. Rock tire top and bottom (Figure 6a or 6b)

FIGURE 6a

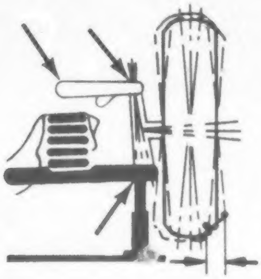
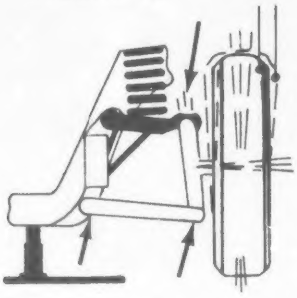


FIGURE 6b



(NOTE: Reject if movement at tire sidewall exceeds maximum tolerance. Do not confuse wheel bearing looseness with ball joint wear.)

JOB SHEET #1

3. Lift and lower the tire in a vertical motion and observe for wear (Figure 7a or 7b)

FIGURE 7a

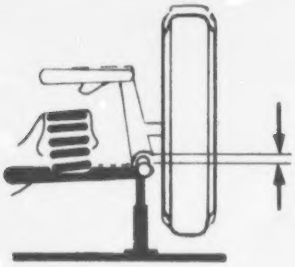
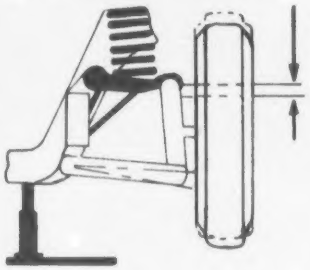


FIGURE 7b



(NOTE: Reject if vertical play in ball joint exceeds maximum tolerance.)

I. Check steering wheel operation for binding or excessive free play

J. Check tire and wheel runout

(NOTE: Excessive tire or wheel runout will cause vibration, regardless of wheel alignment or balance.)

K. Complete all repairs and adjustments that were found necessary during this preliminary check

WHEEL ALIGNMENT
UNIT VI

JOB SHEET #2--ALIGN A FRONT END

I. Tools and equipment

A. Suitable wheel alignment equipment

B. Suitable wrenches for alignment adjustments

C. Manufacturer's wheel alignment specifications

D. Wheel blocks or brake pedal depressor

II. Procedure

(NOTE: All preliminary checks outlined in Job Sheet #1 should be completed before wheel alignment is attempted.)

A. Position vehicle on wheel alignment equipment

(NOTE: Block wheels as required to keep vehicle from rolling on the alignment plates.)

B. Bounce the front end of the vehicle up and down; allow it to settle in its normal running position

(NOTE: Some manufacturers require body height positioning stands to be used in leveling the body before alignment is checked.)

C. Install caster-camber gauge

D. Make caster and camber check; compare it to manufacturer's specifications

E. Make necessary caster-camber adjustments

1. On vehicles with integrated caster-camber adjusters

(NOTE: Adjustments of caster and camber are made with the same adjusters.)

a. With adjusters on the upper control arm

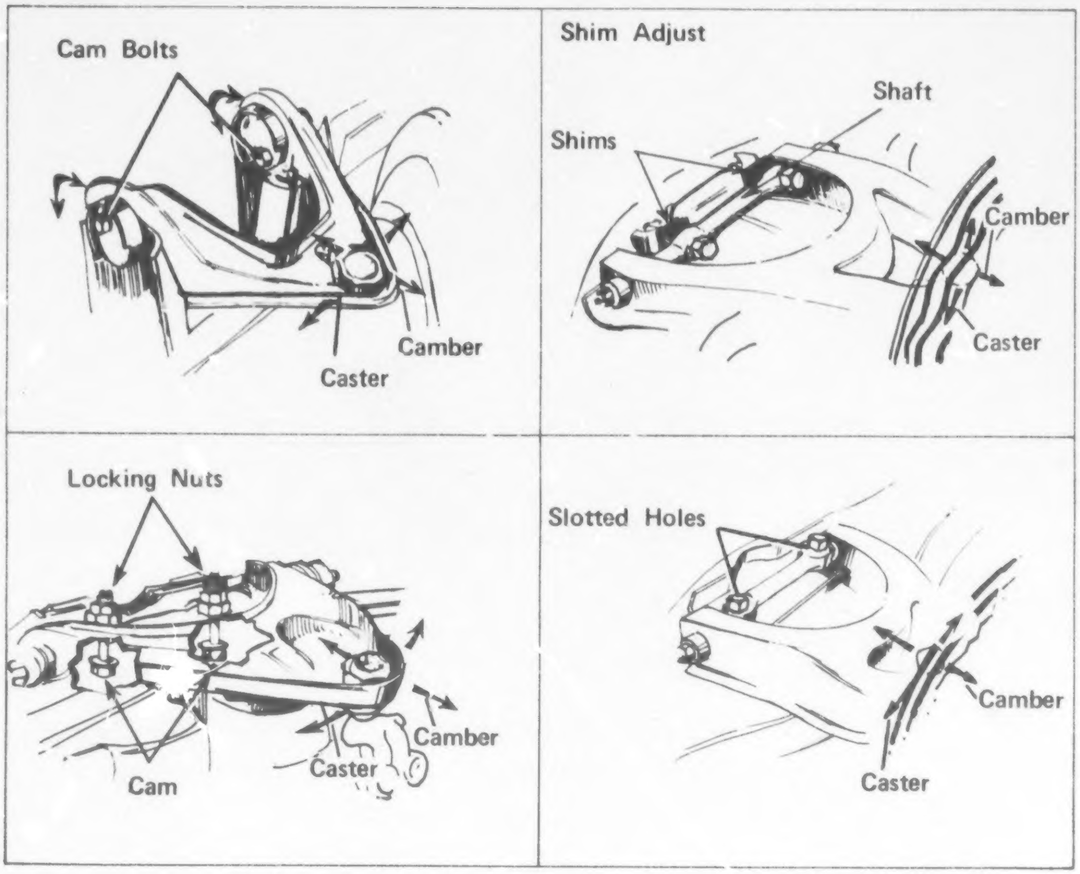
1) Adjust the caster by moving the upper ball joint to the rear for a more positive reading and to the front for a more negative reading

JOB SHEET #2

2) Adjust the camber by moving the upper ball joint outward for a more positive reading and inward for a more negative reading

(NOTE: Figure 1 illustrates the common types of adjusters for upper control arm integrated caster-camber.)

FIGURE 1


Cam Bolts
Camber
Caster
Shim Adjust
Shaft
Shims
Camber
Caster
Locking Nuts
Camber
Caster
Cam
Slotted Holes
Camber
Caster

b. With adjusters on the lower control arm

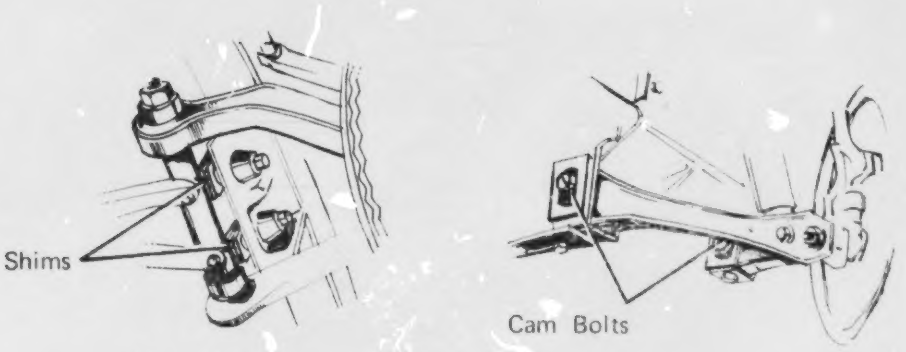
1) Adjust the caster by moving the lower ball joint to the front for a more positive reading and to the rear for a more negative reading

2) Adjust the camber by moving the lower ball joint inward for a more positive reading and outward for a more negative reading

JOB SHEET #2

(NOTE: Use Figure 2 to help determine the type of integrated lower control arm adjuster on your vehicle.)

FIGURE 2



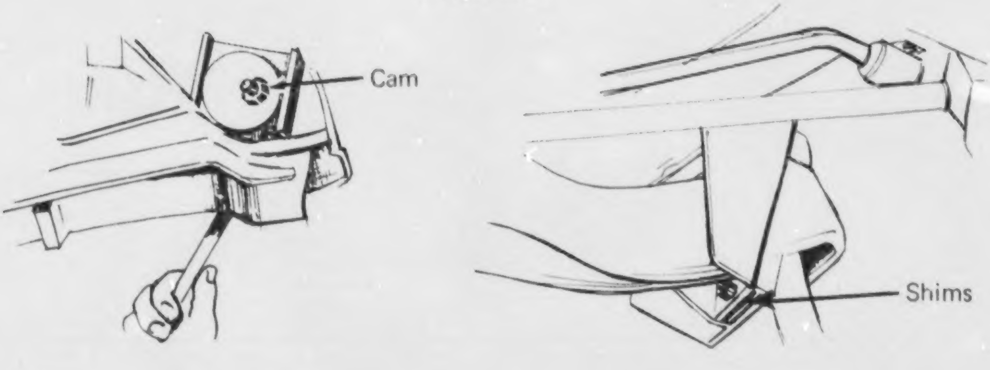
2. On vehicles with separate means for adjusting caster and camber

   (NOTE: Always adjust camber first on vehicles with separate caster-camber adjustments.)

   a. Adjust camber

      1) Move the lower control arm inward for a more positive reading by removing shims or rotating a cam (Figure 3)

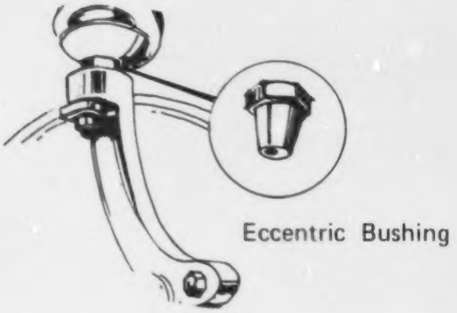
FIGURE 3



JOB SHEET #2

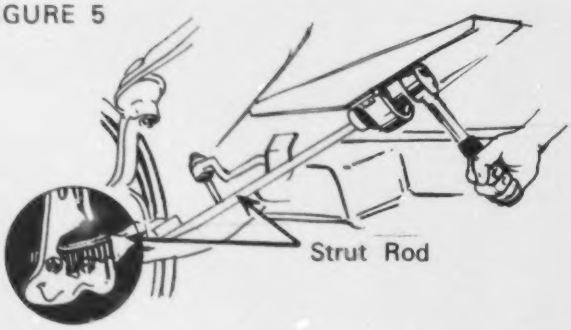
2) Move the upper end of the steering knuckle outward by rotating an eccentric bushing on the upper ball joint stud bolt (Figure 4)

FIGURE 4



b. Adjust caster by adjusting the length of the round strut rod shorter for a more positive reading or longer for a more negative reading (Figure 5)

FIGURE 5

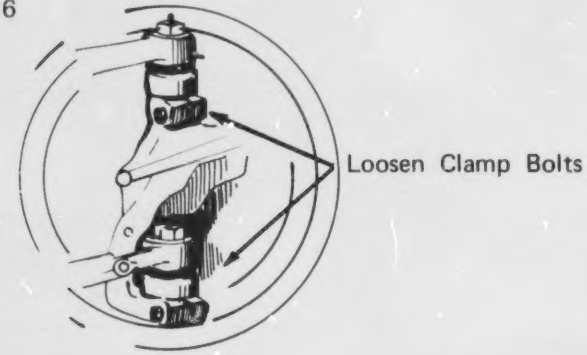


JOB SHEET #2

3. On a trailing arm type front suspension with ball joints at the trailing end of each arm--Adjust camber by loosening the securing screws on the upper ball joint and turning the ball joint (Figure 6)

   (NOTE: Adjustment can be continued on the lower ball joint using the same procedure.)

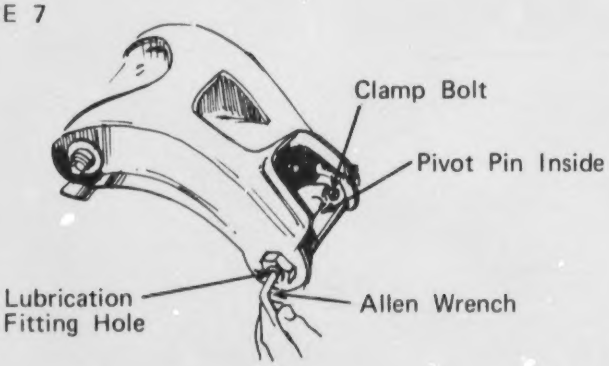
FIGURE 6


Loosen Clamp Bolts

4. On vehicles without ball joints--Adjust caster-camber by rotating the upper control arm pivot pin after removing the lubrication fitting and loosening the clamp bolt (Figure 7)

   (NOTE: This pin is bored off-center and threaded. As the pin is turned, the kingpin inclines fore and aft to change caster and in and out to change camber.)

FIGURE 7


Clamp Bolt
Pivot Pin Inside
Lubrication Fitting Hole
Allen Wrench

F. Set up wheel alignment equipment

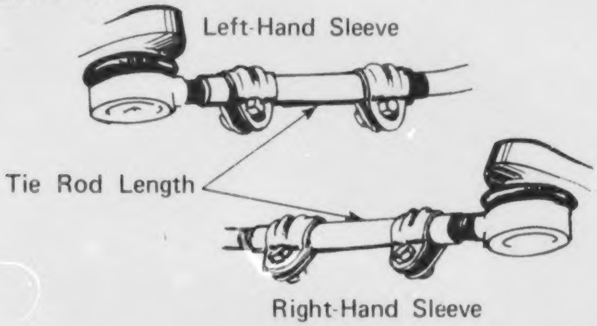
G. Check toe-in

JOB SHEET #2

H. Adjust toe-in

1. Loosen clamp bolts and turn the adjusting sleeve to change tie rod length (Figure 8)

FIGURE 8



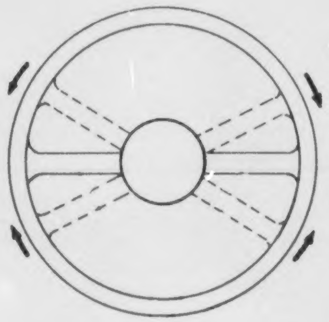
2. Adjust both rods equally to maintain normal spoke position

(NOTE: Figure 9 can be used to center the steering wheel spoke while adjusting toe-in.)

FIGURE 9

When toe-in is correct, turn both connecting rod sleeves upward to adjust spoke position.

Turn both connecting rod sleeves downward to adjust spoke position.



When toe-in is not correct, lengthen left rod to increase toe-in.

Shorten left rod to decrease toe-in.

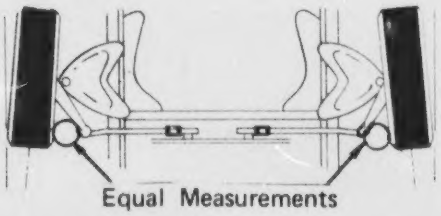
Shorten right rod to decrease toe-in.

Lengthen right rod to increase toe-in.

I. Check toe-out on turns

(NOTE: The angle of a steering arm from brake backing plate to tie rod must be the same for both arms. See Figure 10. If either or both arms are bent, toe-out on turns will be affected. This angle is not adjustable so a bent arm must be replaced.)

FIGURE 10



JOB SHEET #2

J. Check steering axis inclination

(NOTE: This is not adjustable. If this angle does not meet the manufacturer's specifications, either the steering knuckle or its spindle is bent and must be replaced.)

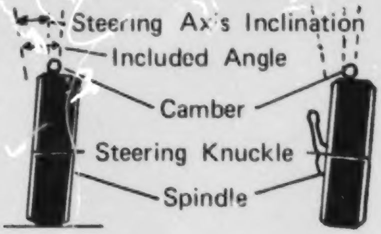
K. Check for bends in steering knuckles

1. Measure degrees of steering axis inclination and caster

2. Add these figures if caster is positive or subtract caster from steering axis inclination if caster is negative to obtain the included angle built into steering knuckles

(NOTE: This angle must be the same for both wheels; if it is not, one steering knuckle is bent. See Figure 11.)

FIGURE 11



L. Check all bolts, clamps, and sleeves to make sure they are safe and sufficiently tightened

M. Remove wheel alignment equipment

N. Replace hub caps and dust covers as required

O. Road test with the instructor

WHEEL ALIGNMENT
UNIT VI

TEST

1. Write the purpose of wheel alignment.

2. Match the wheel alignment angles on the right to the correct definitions.

______a. Inward tilt of the kingpin or ball joint at the top as compared to true vertical

______b. Inward or outward tilt of the wheel at the top

______c. Backward or forward tilt of the kingpin or ball joint at the top

______d. Angle made by the inner wheel as compared to the outer wheel when the vehicle goes into a turn

______e. Amount that wheels are closer together at the extreme front of the tires than at the extreme rear of the tires

1. Camber
2. Caster
3. Toe-in
4. Toe-out on turns
5. Steering axis inclination

3. Match the wheel alignment angles on the right to the correct purposes.

______a. To allow the inner front wheel to roll freely on turns and prevent the outer wheel from dragging

______b. To aid steering stability and establish a pivot point about which the wheel can be easily turned

______c. To enable the front wheels to maintain a straight-ahead position or return to a straight-ahead position after a turn has been completed

______d. To compensate for varying tolerances in the steering linkage and to prevent excessive tire wear

______e. To bring the road contact point of the tire more nearly under the point of load and eliminate excessive tire wear

1. Camber
2. Caster
3. Toe-in
4. Toe-out on turns
5. Steering axis inclination

4. List five preliminary steps to wheel alignment.

   a.

   b.

   c.

   d.

   e.

5. Demonstrate the ability to:

   a. Make preliminary checks before wheel alignment.

   b. Align a front end.

   (NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

WHEEL ALIGNMENT
UNIT VI

ANSWERS TO TEST

1. To place the wheels of a vehicle in correct relative position to enable a free-rolling movement over the road without scuffing, dragging, or slipping

2. a. 5

   b. 1

   c. 2

   d. 4

   e. 3

3. a. 4

   b. 5

   c. 2

   d. 3

   e. 1

4. Any five of the following:

   a. Tire conditions

   b. Tire pressure

   c. Wheel runout

   d. Wheel bearing adjustment

   e. Front-end looseness

   f. Shock absorbers

   g. Spring sag

5. Performance skills evaluated to the satisfaction of the instructor

BRAKE SYSTEM
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to describe brake operation and identify the parts of the brake system. The student should be able to demonstrate the ability to remove and replace brake drums and brake shoes, recondition a master cylinder and wheel cylinder, and adjust and bleed a brake system. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Write the purpose of the brake system.
2. Match terms associated with the brake system to the correct definitions.
3. Identify components of the standard brake system.
4. Identify components of the tandem or dual brake system.
5. Identify the parts of a standard master cylinder.
6. Identify the parts of a tandem master cylinder.
7. Identify the parts of a wheel cylinder.
8. Identify the parts of a standard brake assembly.
9. Identify the types of self-adjusting brake systems.
10. Describe brake operation.
11. Demonstrate the ability to:
    a. Adjust brake shoes.
    b. Bleed the brake system.
    c. Remove, inspect, and replace brake drums.
    d. Remove and replace brake shoes.
    e. Remove, recondition, and replace a wheel cylinder.
    f. Remove, recondition, and replace a master cylinder.
    g. Remove, recondition, and replace a tandem master cylinder.

BRAKE SYSTEM
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Demonstrate and discuss procedures outlined in the job sheets.

  G. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Demonstrate the ability to accomplish the procedures outlined in the job sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Components of the Standard Brake System

    2. TM 2--Components of the Tandem or Dual Brake System

    3. TM 3--Parts of the Standard Master Cylinder

    4. TM 4--Parts of the Tandem Master Cylinder

5. TM 5--Parts of the Wheel Cylinder

6. TM 6--Parts of the Standard Brake Assembly

7. TM 7--Cable Pull Self-Adjusting Brake System (Early Type)

8. TM 8--Cable Pull Self-Adjusting Brake System (Late Type)

9. TM 9--Lever Type Self-Adjusting Brake System

10. TM 10--Brake Operation

D. Job sheets

1. Job Sheet #1--Adjust Brake Shoes

2. Job Sheet #2--Bleed the Brake System

3. Job Sheet #3--Remove, Inspect, and Replace Brake Drums

4. Job Sheet #4--Remove and Replace Brake Shoes

5. Job Sheet #5--Remove, Recondition, and Replace a Wheel Cylinder

6. Job Sheet #6--Remove, Recondition, and Replace a Standard Master Cylinder

7. Job Sheet #7--Remove, Recondition, and Replace a Tandem Master Cylinder

E. Test

F. Answers to test

II. References:

A. Toboldt, William K., and Purvis, Jud. *Motor Service's Automotive Encyclopedia*. Homewood, Illinois: Goodheart-Willcox Co., 1965.

B. *Brake Service Manual*, no. 7003. Chicago: AMMCO Tools Inc., 1968.

C. *Drum Brake Service Manual*. Bulletin 17011. Delco-Moraine Division, General Motors Corp., 1967.

BRAKE SYSTEM
UNIT I

INFORMATION SHEET

I. Purpose of the brake system--To provide a method of slowing or stopping the car by the driver

II. Terms and definitions

   A. Hydraulic--Refers to fluid in motion

   B. Brake fluid--Special fluid used in hydraulic brake systems

   (NOTE: It is important to use an extra heavy duty brake fluid to give maximum protection to the hydraulic system. This fluid is colored blue for identification purposes.)

   C. Hydraulic cylinder--Cylinder that produces or is controlled by the motion of fluid

   D. Bleeding the brakes--Refers to the removal of air from the hydraulic brake system

   E. Master cylinder--Hydraulic cylinder used to force the brake fluid to the individual wheel cylinders when applying the brakes

   F. Brake line--High pressure line used to carry the brake fluid from the master cylinder to the wheel cylinders

   G. Wheel cylinder--Hydraulic cylinder which is actuated by hydraulic pressure to force the brake lining into contact with the brake drum

   H. Brake shoe--That part of the brake assembly to which the brake lining is attached

   I. Brake drum--Cast iron or aluminum housing that rotates around the brake assembly providing a smooth surface for the brake shoes to contact and exert braking action

III. Components of the standard brake system (Transparency 1)

   A. Master cylinder

   B. Brake line

   C. Wheel cylinder

   D. Brake shoe

   E. Brake drum

INFORMATION SHEET

IV. Components of the tandem or dual brake system (Transparency 2)

  A. Tandem or dual master cylinder

  B. Pressure differential valve and brake warning light switch

  C. Brake line

  D. Brake shoe

  E. Brake drum

  F. Wheel cylinder

  G. Brake flex hose

  H. Backing plate

V. Parts of a standard master cylinder (Transparency 3)

  A. Rubber valve seat washer

  B. Residual pressure check valve assembly

  C. Piston return spring

  D. Primary cup

  E. Piston

  F. Secondary cup

  G. Piston lock ring

  H. Boot

  I. Push rod

  J. Fluid reservoir

  K. Filler cap

VI. Parts of a tandem master cylinder (Transparency 4)

  A. Retainer bail

  B. Residual pressure check valve

  C. Tube seat

  D. Piston stop bolt

INFORMATION SHEET

E. Return spring

F. Cup protector

G. Secondary piston assembly

H. Primary piston assembly

I. Push rod

J. Boot

(NOTE: Master cylinders on power brake units usually do not contain push rods and boots.)

K. Snap ring

L. Master cylinder

M. Diaphragm gasket

N. Cover

VII. Parts of the wheel cylinder (Transparency 5)

A. Boot

B. Piston

C. Cup expander

D. Spring

E. Expander

F. Cylinder

G. Bleeder screw

VIII. Parts of the standard brake assembly (Transparency 6)

A. Anchor pin

B. Connecting link

C. Primary brake shoe and lining

D. Secondary brake shoe and lining

INFORMATION SHEET

E. Backing plate

F. Adjusting screw spring

G. Adjusting screw

H. Star wheel

I. Return spring

J. Brake shoe retainer

IX. Types of self-adjusting brake systems

A. Cable pull, early type (Transparency 7)

B. Cable pull, late type (Transparency 8)

C. Lever type (Transparency 9)

X. Brake operation (Transparency 10)

A. As the brake pedal is depressed

1. The master cylinder forces brake fluid through the check valve into the brake lines

2. The fluid travels through the brake lines to the wheel cylinders

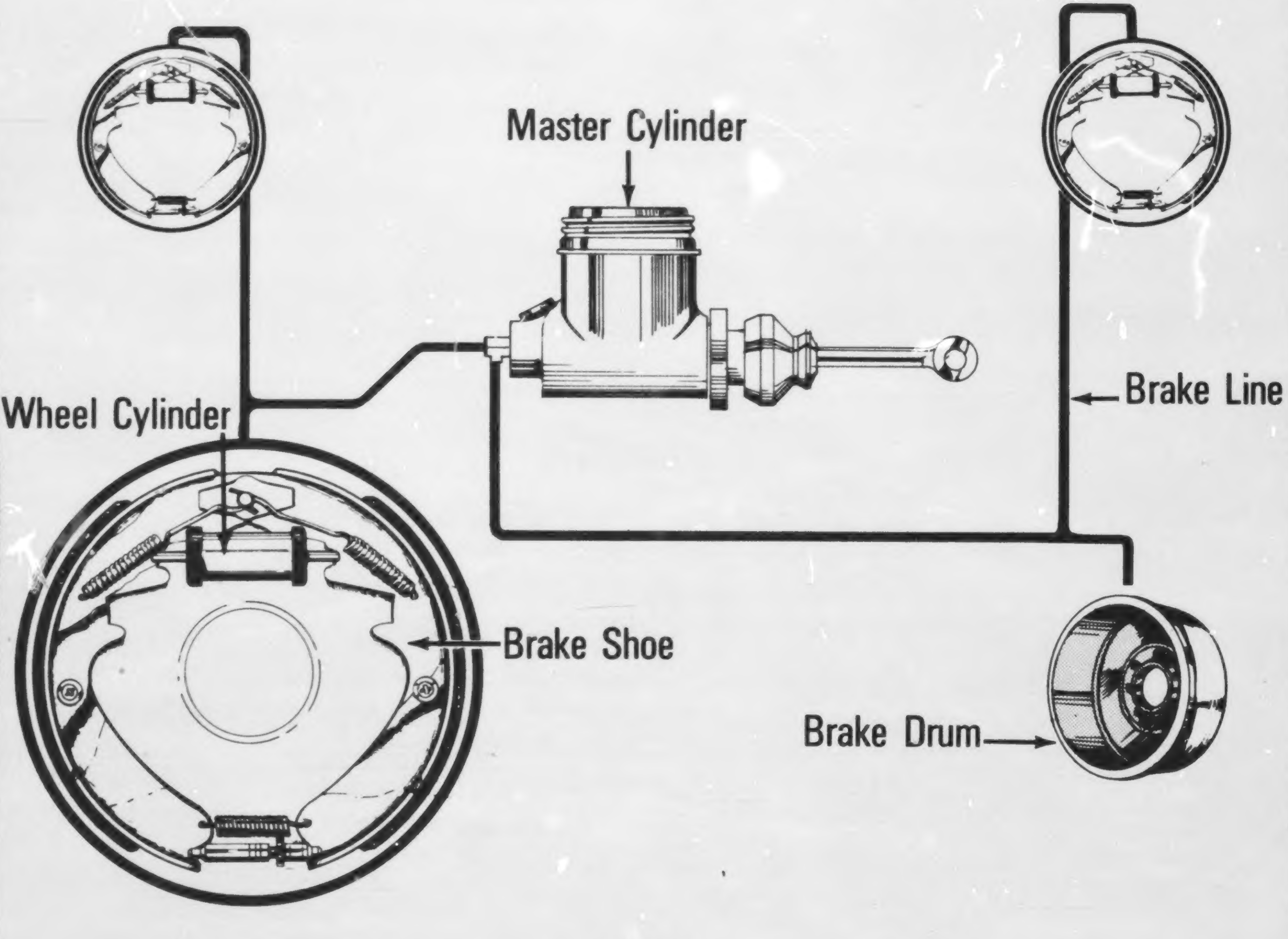
3. The force of brake fluid by the master cylinder causes the wheel cylinder cups and pistons to move outward

4. The movement caused by the wheel cylinder pistons forces the brake shoe and lining to make contact with the brake drum

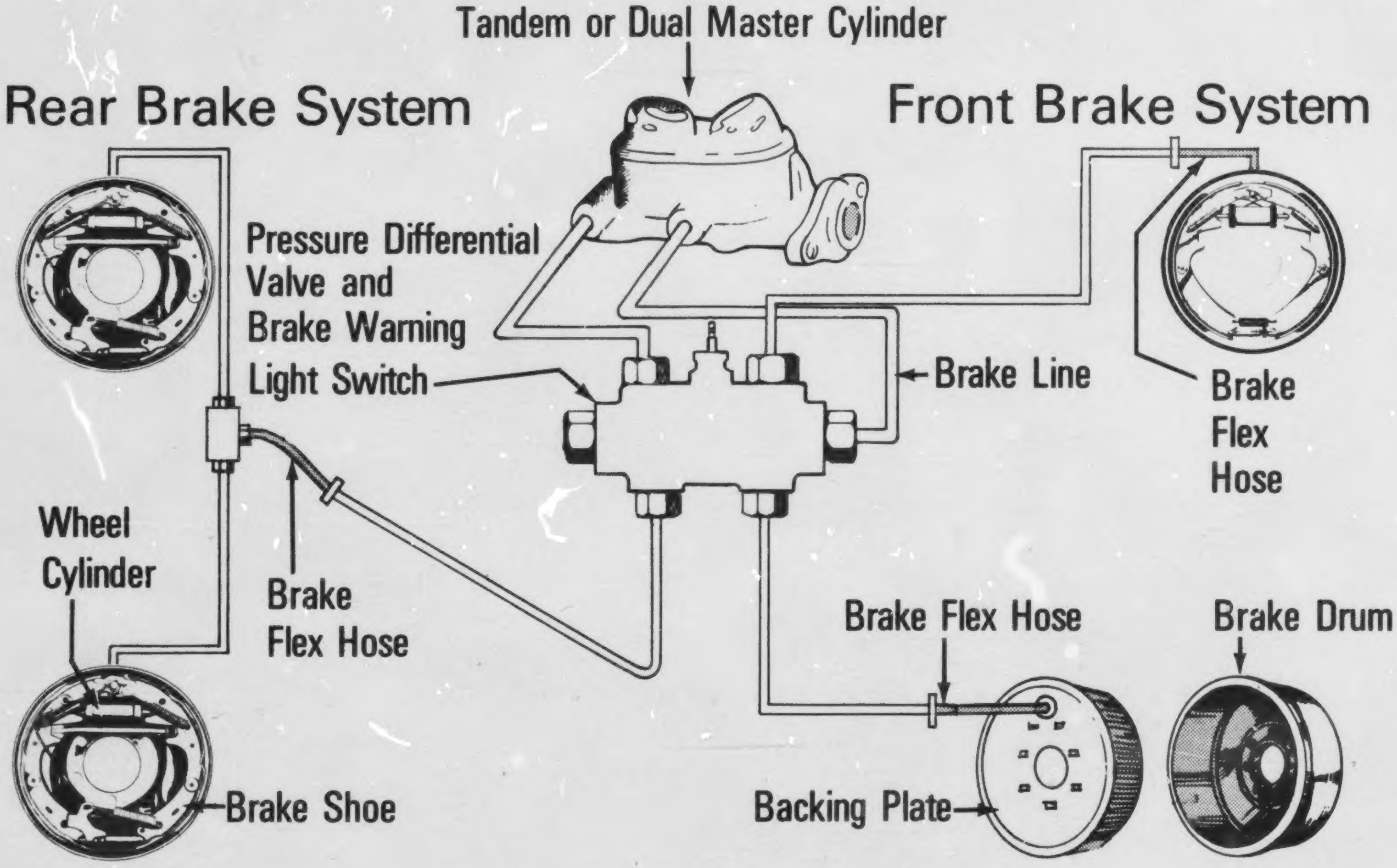
5. The force of the fluid and the contact of the brake lining with the brake drum cause the vehicle to slow or stop

B. As the brake pedal is released--The return springs pull the brake shoes back to the stop position, forcing the brake fluid to return to the master cylinder reservoir

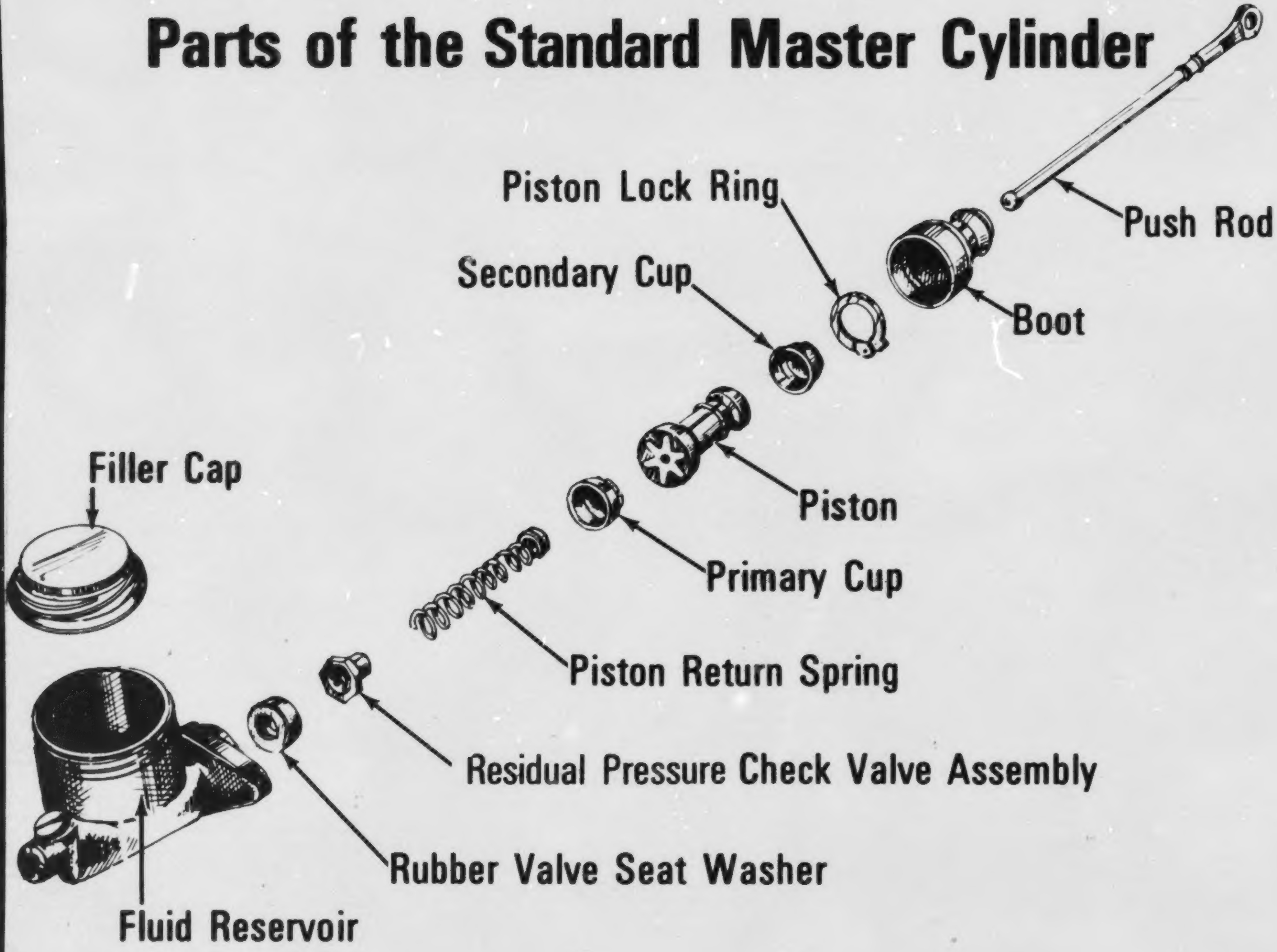
Components of the Standard Brake System


Master Cylinder
Brake Line
Wheel Cylinder
Brake Shoe
Brake Drum

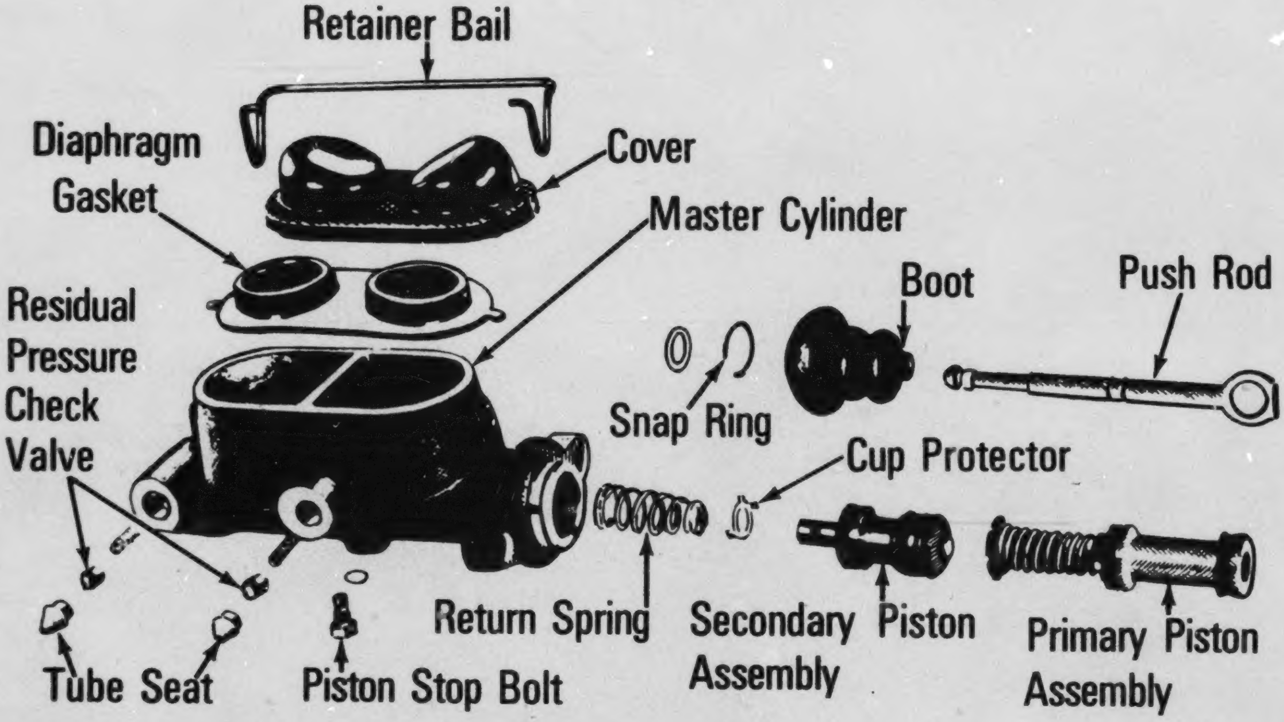
Components of the Tandem or Dual Brake System


Tandem or Dual Master Cylinder
Rear Brake System
Front Brake System
Pressure Differential Valve and Brake Warning Light Switch
Brake Line
Brake Flex Hose
Wheel Cylinder
Brake Flex Hose
Brake Flex Hose
Brake Drum
Brake Shoe
Backing Plate

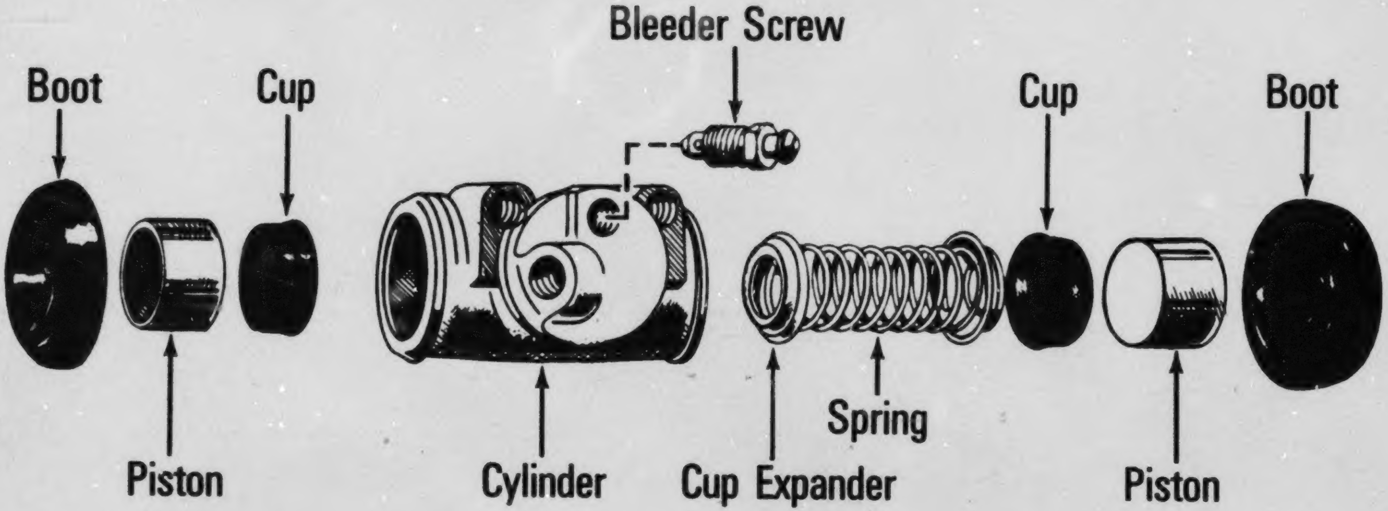
Parts of the Standard Master Cylinder


Piston Lock Ring
Push Rod
Secondary Cup
Boot
Piston
Filler Cap
Primary Cup
Piston Return Spring
Residual Pressure Check Valve Assembly
Rubber Valve Seat Washer
Fluid Reservoir

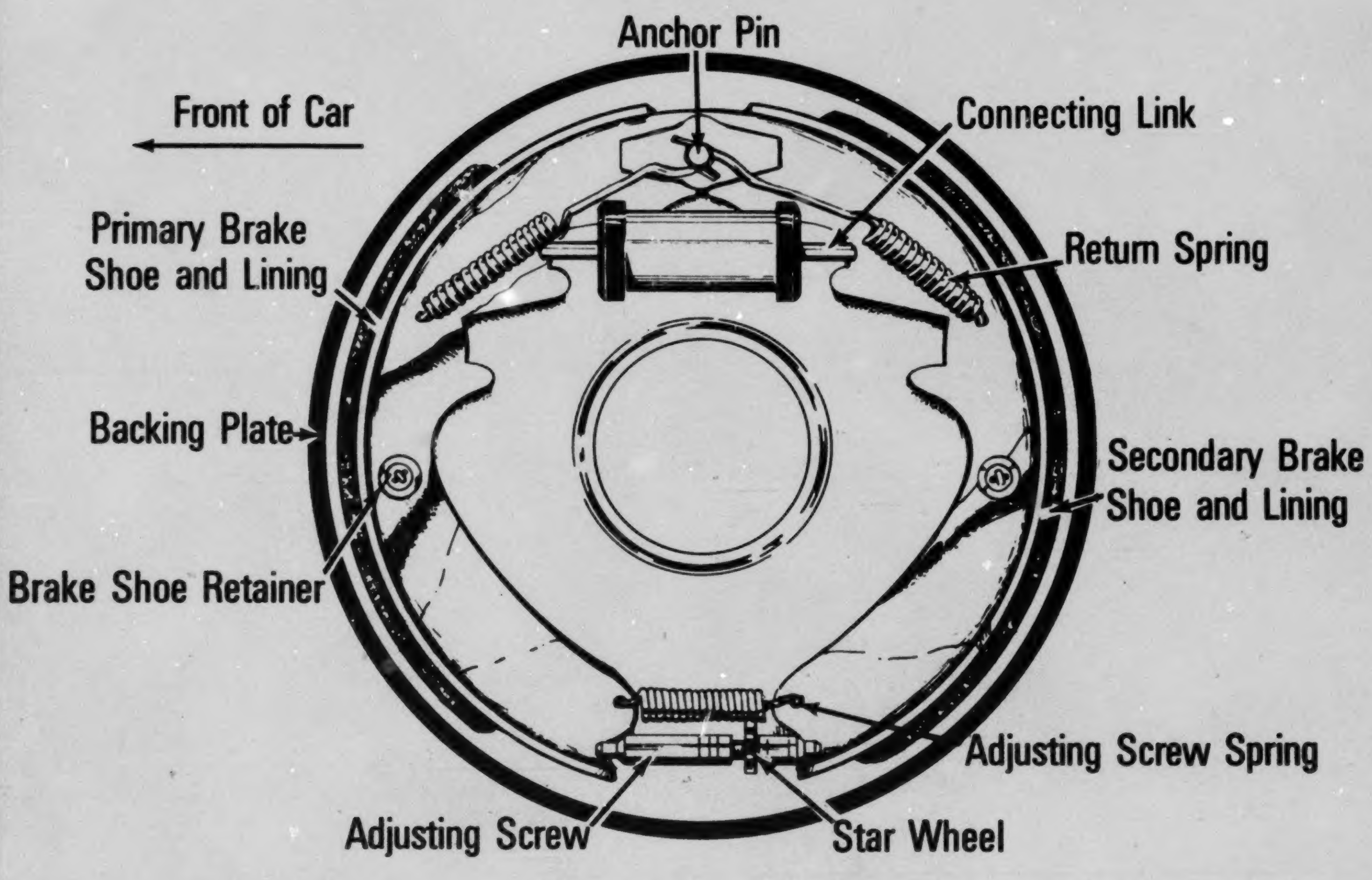
Parts of the Tandem Master Cylinder


Retainer Bail
Diaphragm Gasket
Cover
Master Cylinder
Boot
Push Rod
Residual Pressure Check Valve
Snap Ring
Cup Protector
Return Spring
Secondary Piston Assembly
Primary Piston Assembly
Tube Seat
Piston Stop Bolt

Parts of the Wheel Cylinder

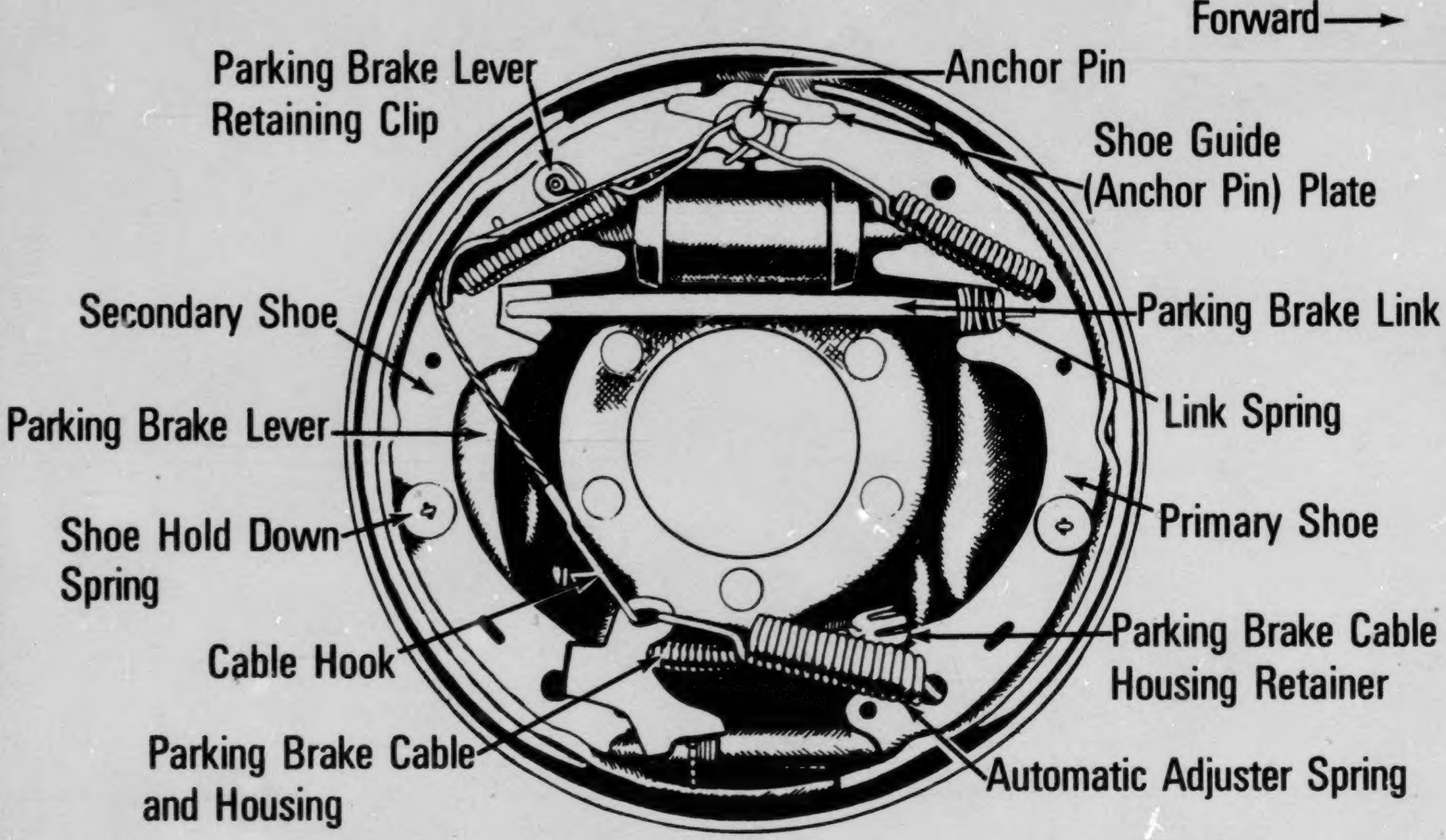

Bleeder Screw
Boot
Cup
Cup
Boot
Piston
Cylinder
Cup Expander
Spring
Piston

Parts of the Standard Brake Assembly


Anchor Pin
Front of Car
Connecting Link
Primary Brake Shoe and Lining
Return Spring
Backing Plate
Secondary Brake Shoe and Lining
Brake Shoe Retainer
Adjusting Screw Spring
Adjusting Screw
Star Wheel

Cable Pull Self-Adjusting Brake System

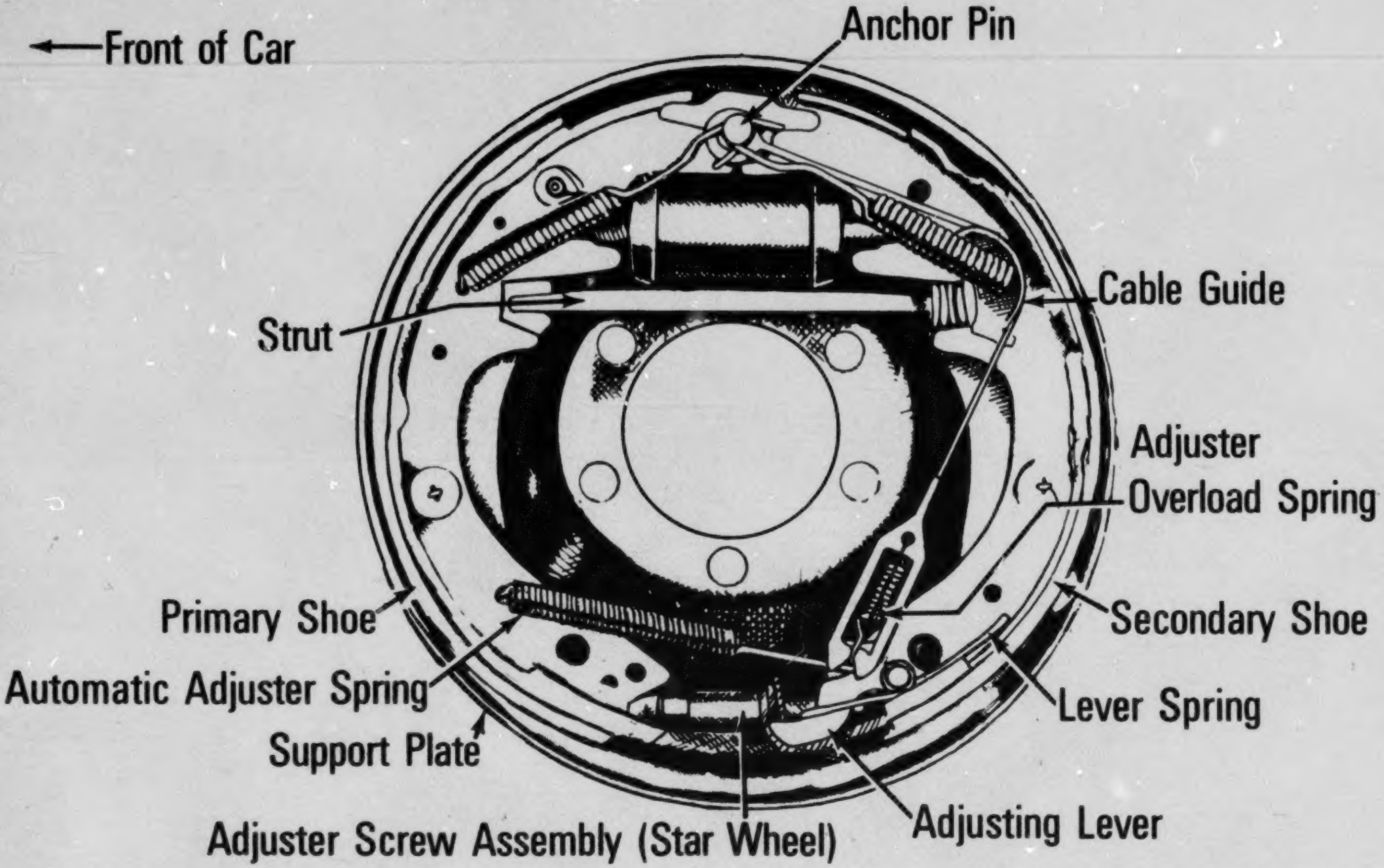
(Early Type)


Forward →
Parking Brake Lever Retaining Clip
Anchor Pin
Shoe Guide (Anchor Pin) Plate
Secondary Shoe
Parking Brake Link
Link Spring
Parking Brake Lever
Primary Shoe
Shoe Hold Down Spring
Parking Brake Cable Housing Retainer
Cable Hook
Parking Brake Cable and Housing
Automatic Adjuster Spring

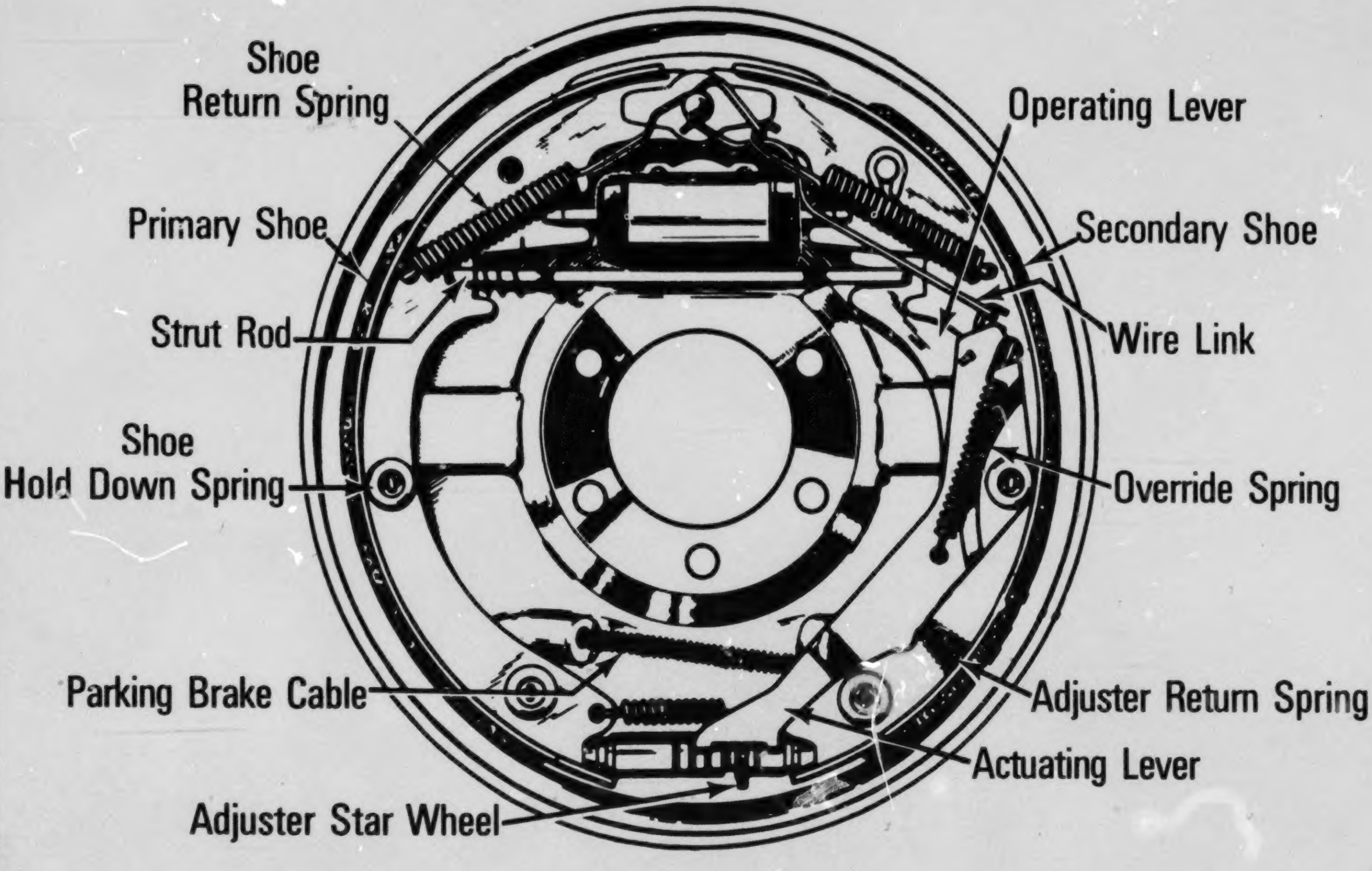
Rear Brake

Cable Pull Self-Adjusting Brake System

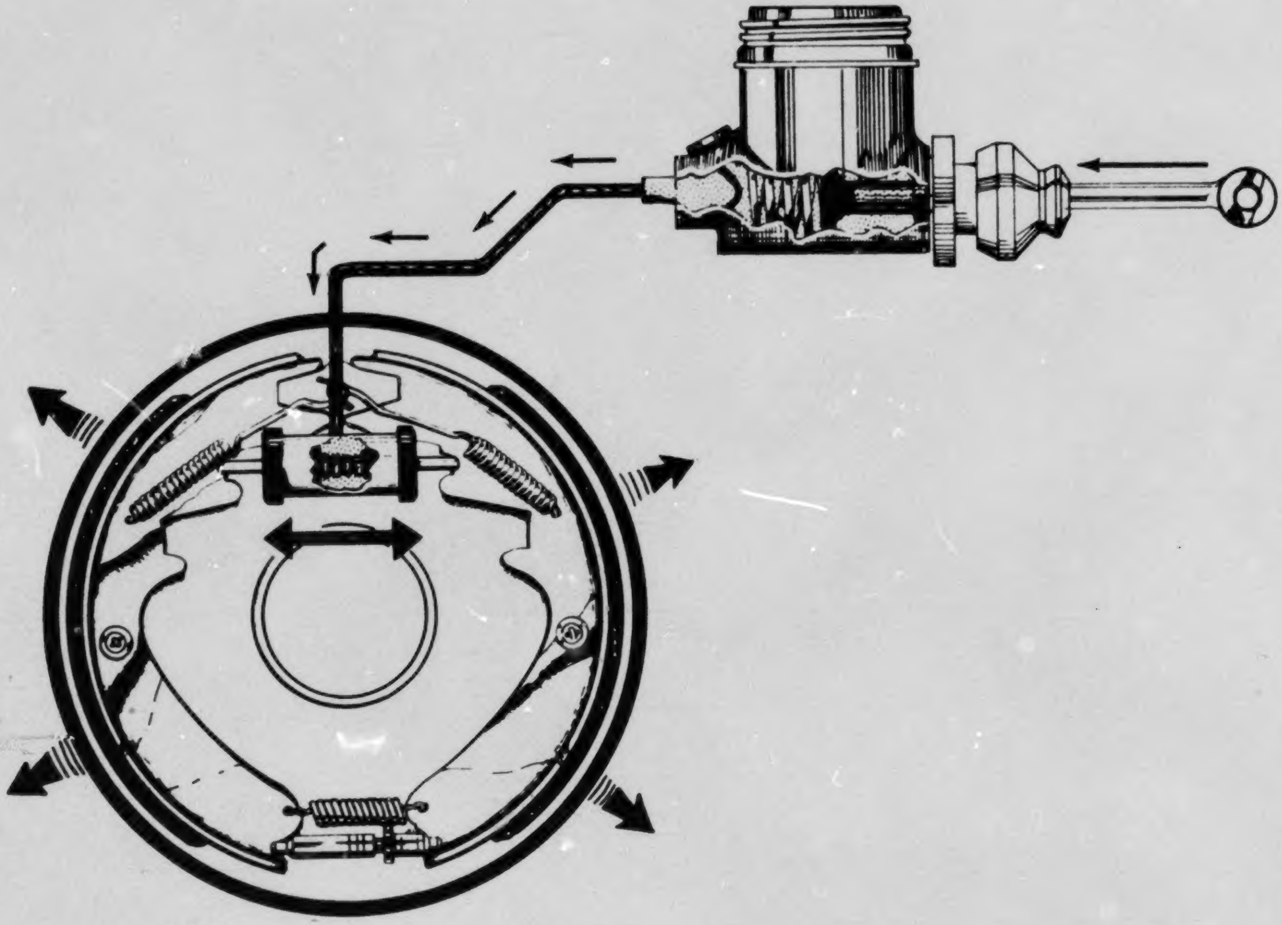
(Late Type)


Front of Car
Anchor Pin
Cable Guide
Strut
Adjuster
Overload Spring
Primary Shoe
Secondary Shoe
Automatic Adjuster Spring
Lever Spring
Support Plate
Adjusting Lever
Adjuster Screw Assembly (Star Wheel)

Lever Type Self-Adjusting Brake System


Shoe Return Spring
Operating Lever
Primary Shoe
Secondary Shoe
Strut Rod
Wire Link
Shoe Hold Down Spring
Override Spring
Parking Brake Cable
Adjuster Return Spring
Actuating Lever
Adjuster Star Wheel

Brake Operation



BRAKE SYSTEM
UNIT I

JOB SHEET #1--ADJUST BRAKE SHOES

I. Tools and equipment

  A. Brake adjustment tool

  B. Screwdriver, long thin-bladed

  C. Floor jack

  D. Jack stands

  E. Drum-to-shoe gauge

II. Procedure for minor adjustment on manually adjusted brakes

  A. Support vehicle on jack stands

  B. Pull a wheel and brake drum to inspect brake lining

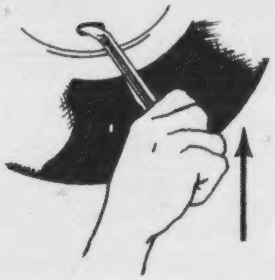
  C. Make sure parking brake cables are fully released

  D. Remove cover from brake adjuster access hole

  E. Insert star wheel adjusting tool

  F. Move the handle of the adjusting tool upward to tighten or expand the brake shoes as adjusting tool contacts the star wheel (Figure 1)

FIGURE 1



Manually Adjusted Brake

  G. Adjust the brake shoes until it requires both hands to rotate the drum

JOB SHEET #1

H. Back off the star wheel 10 to 16 clicks

(NOTE: The adjusting tool handle is moved downward to back off the brake shoes.)

I. Make sure the brake drum turns freely after backing off brake shoes

(NOTE: Check pedal height and feel to determine if other service is required.)

J. Install brake adjuster access hole covers

K. Remove jack stands

L. Lower car to floor

M. Check brake fluid

III. Procedure for adjustment on self-adjusting brakes

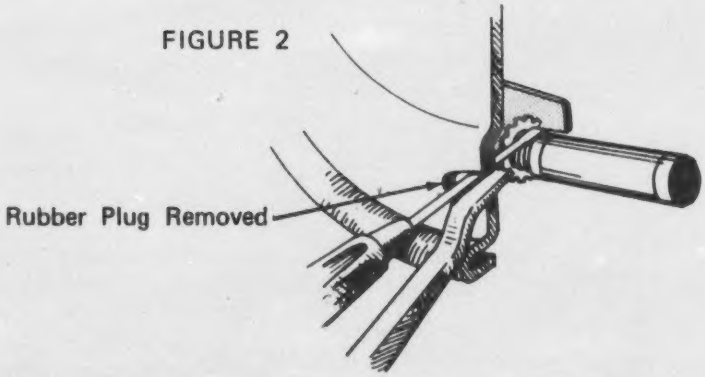
(NOTE: When self-adjusting brakes need manual adjustment, the system should be inspected before adjustments are made.)

A. Inspect the self-adjusting mechanism

1. Support the vehicle on jack stands
2. Remove the tire and wheel assembly
3. Remove the brake drum

(NOTE: Back off brake shoe adjustment to aid drum removal by inserting an ice pick or small screwdriver through the brake adjusting access hole and disengaging the adjusting lever from the star wheel. Back off the star wheel adjuster. See Figure 2.)

FIGURE 2



JOB SHEET #1

4. Inspect the self-adjusting mechanism for broken or improperly installed parts

5. Hold the adjusting lever out of engagement with the star wheel adjusting screw

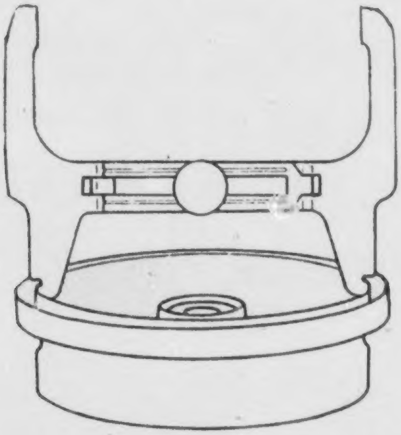
6. Rotate the star wheel adjusting screw to make sure it is free turning

   (NOTE: Disassemble, clean, and lubricate the adjustment screw if finger pressure will not turn it.)

B. Make manual adjustment on self-adjusting brakes with brake drum removed

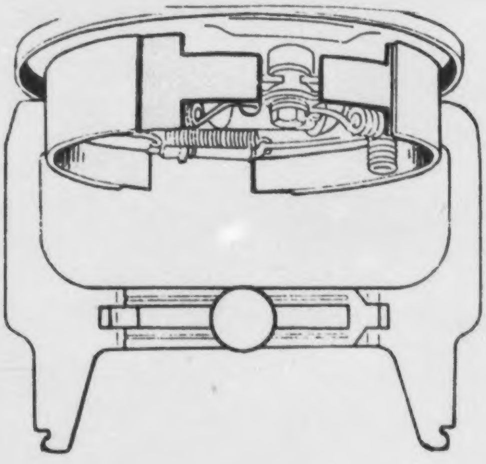
1. Set the drum-to-shoe gauge to brake drum size (Figure 3)

FIGURE 3



2. Place drum-to-shoe gauge on brake shoes (Figure 4)

FIGURE 4



JOB SHEET #1

3. Adjust the brake shoe diameter to fit the gauge

4. Rotate the gauge around the shoes to check the setting

5. Install the brake drum

   (NOTE: The brake drum should turn freely but with a slight drag.)

6. Install brake adjuster hole plugs

7. Remove jack stands

8. Lower the vehicle to the floor

9. Check brake fluid level in the master cylinder

10. Make final adjustment by backing the vehicle and applying the brakes several times with a minimum of 50 pounds pressure on the pedal

    (NOTE: After each stop the vehicle must be moved forward.)

11. Road test the vehicle to check brake operation

BRAKE SYSTEM
UNIT I

JOB SHEET #2--BLEED THE BRAKE SYSTEM

I. Tools and equipment

   A. Combination end wrenches, 1/4" - 1/2" (6 mm - 13 mm)

   B. Adjustable end wrench, 10" (25 cm) long

   C. Pressure tank brake bleeding equipment

   D. Brake fluid

   E. Clean, clear container

   F. Bleeder hose

   G. Brake bleeder wrenches as required

II. Procedure for manually bleeding a hydraulic system

   A. Fill the master cylinder with clean, fresh brake fluid

   (NOTE: Use care when handling brake fluid; it will damage automobile finishes.)

   (CAUTION: Do not allow the master cylinder reservoir to become empty of fluid during the bleeding process.)

   B. Attach a bleeder hose to the bleeder screw of the wheel cylinder

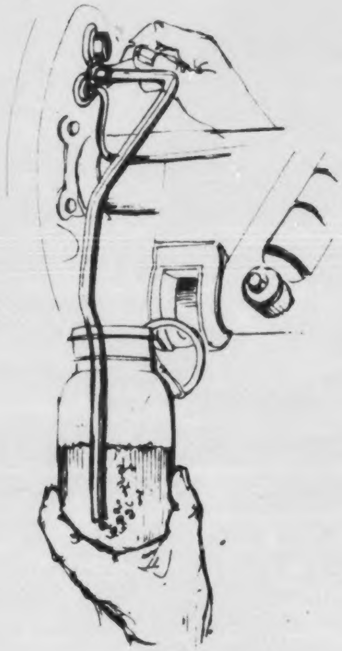
   (NOTE: Bleed right rear wheel cylinder first on single cylinder master cylinders, but treat tandem master cylinder type as two separate systems by bleeding either the front or rear brakes first.)

   C. Place the loose end of the bleeder hose in a clear container partially filled with brake fluid

   (NOTE: See Figure 1 on the following page. The end of the bleeder hose must be completely submerged.)

JOB SHEET #2

FIGURE 1



(CAUTION: Do not reuse the fluid from the container; it is contaminated.)

D. Open wheel cylinder bleeder screw approximately 3/4 of a turn

(NOTE: Use 6-point box end wrench on bleeder screw.)

E. Have a helper slowly depress the brake pedal until it reaches the end of travel

F. Close the wheel cylinder bleeder screw

G. Have helper to allow the pedal to return slowly to the fully released position

H. Repeat this operation until brake fluid flows in a solid stream from the end of the bleeder hose

I. Close wheel cylinder bleeder screw tightly

J. Remove the bleeder hose from the wheel cylinder bleeder screw

K. Refill the master cylinder

L. Repeat the bleeding operation for the remaining wheel cylinders

M. Refill master cylinder reservoir to the proper level with clean, fresh brake fluid upon completion of bleeding operation

JOB SHEET #2

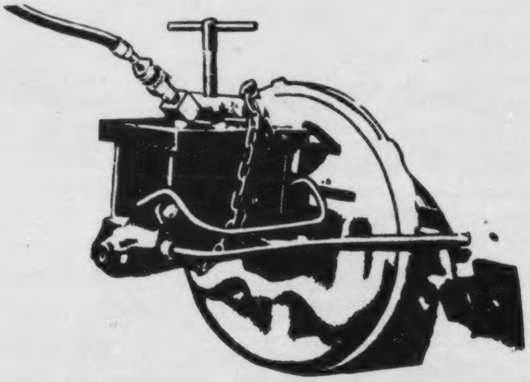
III. Procedure for pressure bleeding a hydraulic system

A. Fill the master cylinder with clean, fresh brake fluid

(NOTE: Use care when handling brake fluid; it will damage automobile finishes.)

B. Install the special bleeding adapter to the master cylinder (Figure 2)

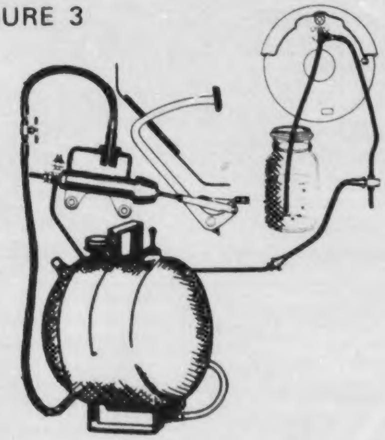
FIGURE 2



C. Make sure the pressure bleeder tank is at least 1/3 full of fluid

D. Make sure the pressure bleeder tank has from 25-35 psi (1.40 - 1.75 kg/cm^2) of pressure on the brake fluid (Figure 3)

FIGURE 3



JOB SHEET #2

(NOTE: Follow equipment manufacturer's specifications on bleeder operation.)

E. Connect the bleeder tank hose to the adapter at the master cylinder

F. Connect one end of a bleeder hose to the wheel cylinder bleeder screw

G. Place the loose end of the bleeder hose in a clear container partially filled with brake fluid

(NOTE: The end of the bleeder hose must be completely submerged.)

(CAUTION: Do not reuse the fluid from the container; it is contaminated.)

H. Open the wheel cylinder bleeder screw approximately 3/4 of a turn

(NOTE: Use 6-point box end wrench on bleeder screw.)

I. Allow fluid to flow into the container until it is a solid stream completely free of air bubbles

J. Close the bleeder screw securely

K. Remove bleeder hose and continue the procedure for each of the remaining wheel cylinders

L. Disconnect the brake pressure bleeder

M. Remove the master cylinder adapter

N. Check brake fluid level of the master cylinder before reinstalling cap

BRAKE SYSTEM
UNIT I

JOB SHEET #3--REMOVE, INSPECT, AND REPLACE BRAKE DRUMS

I. Tools and equipment

  A. Floor jack

  B. Jack stands

  C. Pliers

  D. Channel lock pliers

  E. Diagonal cutting pliers

  F. Lug wrench

  G. Torque wrench

  H. Sockets to fit lug bolts

  I. Brake adjustment tool

  J. Rubber hammer

  K. Screwdriver

  L. Shop towels

  M. Creeper

II. Procedure

  A. Support vehicle on jack stands

  B. Remove the wheels

  (NOTE: Some vehicles have left-hand lug bolts; use care to avoid twisting them off.)

  C. Remove the grease cap

  (NOTE: See Figure 1 on the following page.)

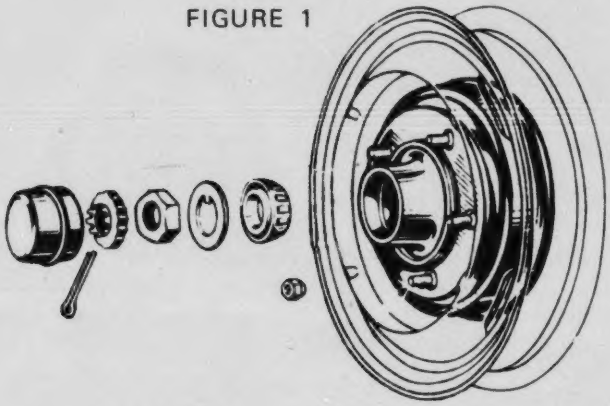
  D. Remove the cotter pin and spindle nut

  E. Remove the outer washer and wheel bearing

JOB SHEET #3

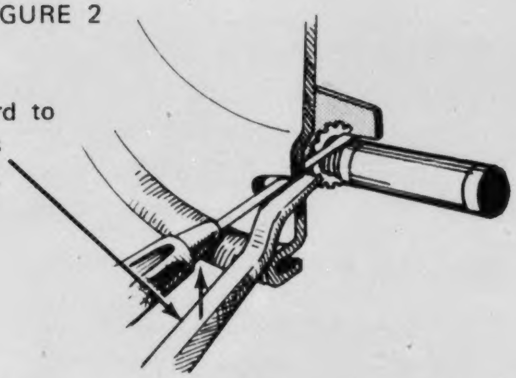
F. Remove the front brake drum (Figure 1)

FIGURE 1



(NOTE: It may be necessary to back off the brake shoe adjustment to allow the brake drum to be removed. See Figure 2.)

FIGURE 2



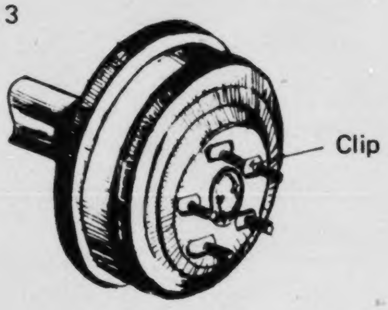
Move Handle Upward to Retract Brake Shoes

(CAUTION: Protect the wheel bearings from dirt; use care to avoid dropping the brake drum.)

JOB SHEET #3

G. Remove the metal clip retainers on the rear brake drums (Figure 3)

FIGURE 3



H. Back off brake shoe adjustment as required

I. Remove rear brake drums

J. Inspect brake shoes and determine if replacement is necessary

(NOTE: Consult the instructor.)

K. Clean the brake drums

L. Inspect the brake drums for cracks, scores, or any defect on the friction surface; check for wear, taper, or out-of-round conditions

M. Service brake drums as required

N. Perform other brake service as required

O. Replace the front brake drums

(NOTE: Make sure the wheel bearings and seals are properly lubricated and in place.)

P. Install the outer wheel bearing, washer, and spindle nut; adjust according to manufacturer's specifications

Q. Install the nut lock, if used, and a new cotter pin

R. Install grease cap

S. Replace the rear brake drums

T. Install drum retainer clips

JOB SHEET #3

U. Install wheels and tires

V. Torque lug bolts in sequence to manufacturer's specifications

(CAUTION: Do not overtighten lugs; brake drums may be damaged.)

W. Make additional brake adjustments as required

X. Remove jack stands

Y. Lower vehicle to floor

BRAKE SYSTEM
UNIT I

JOB SHEET #4--REMOVE AND REPLACE BRAKE SHOES

I. Tools and equipment

A. Floor jack

B. Jack stands

C. Brake shoe removal tools

D. Channel lock pliers

E. Diagonal cutting pliers

F. Pliers

G. Rubber hammer

H. Screwdriver

I. Lubricants, wheel-bearing and high temperature

J. Shop towels

K. Lug wrench

L. Torque wrench

M. Combination end wrenches, 3/8" - 5/8" (8 mm - 15 mm)

N. Wheel cylinder clamps, 4

II. Procedure

A. Support vehicle on jack stands

B. Remove the wheels

(NOTE: Some vehicles have left-hand lug bolts; use care to avoid twisting them off.)

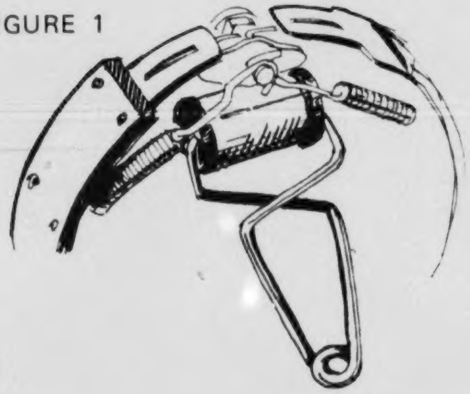
C. Remove the brake drums

(NOTE: Blow loose dirt from brake lining with compressed air.)

JOB SHEET #4

D. Install wheel cylinder clamps on the wheel cylinders to prevent fluid leakage (Figure 1)

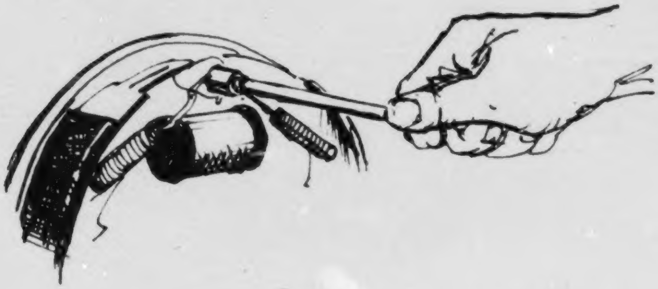
FIGURE 1



E. Remove brake shoes

1. Remove the brake shoe return springs (Figure 2)

FIGURE 2

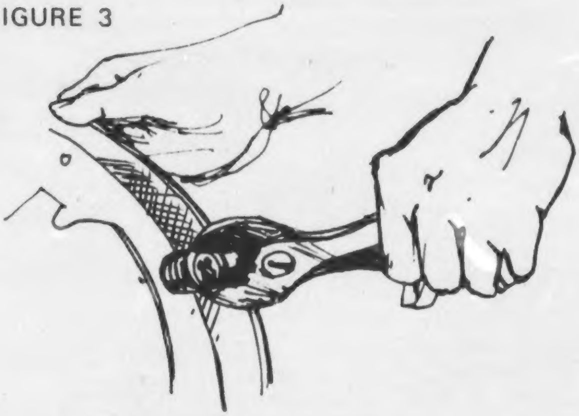


(NOTE: Note the color, type, and location of the brake shoe springs so each will be replaced in its correct position. Avoid bending spring hook.)

JOB SHEET #4

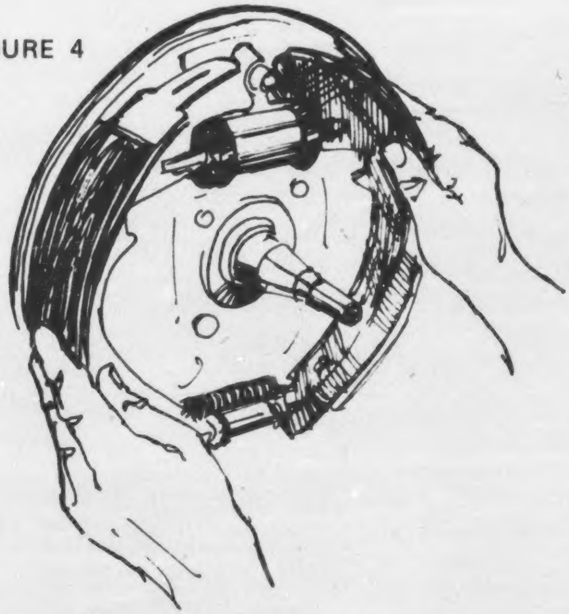
2. Remove the brake shoe retaining or hold-down parts (Figure 3)

FIGURE 3



3. Spread the anchor ends of the brake shoes and disengage from the wheel cylinder struts (Figure 4)

FIGURE 4



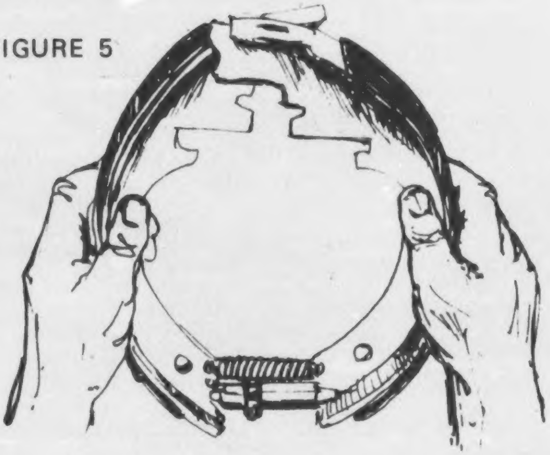
4. Remove brake shoe assembly from backing plate

   (NOTE: If brake shoes are to be reused, mark them so they can be replaced in the same position.)

JOB SHEET #4

5. Overlap the anchor end of the shoes to relieve spring tension (Figure 5)

FIGURE 5



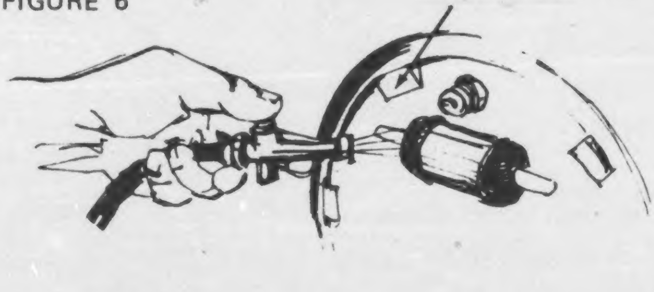
6. Unhook and remove the brake shoe adjusting screw spring and adjusting screw assembly

F. Clean and inspect parts

1. Clean the backing plate, struts, levers, and all metal parts to be reused

(NOTE: Blow off loose dirt with compressed air. See Figure 6.)

FIGURE 6



JOB SHEET #4

2. Check the backing plates to make sure they are free of corrosion or other surface defects and that shoe pad areas are smooth

3. Check for oil leakage past the wheel bearing seals on the rear wheels

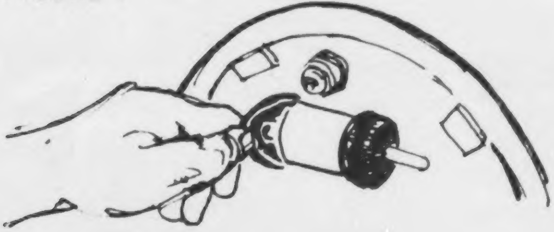
   (NOTE: Such leakage will indicate the need for additional service work.)

4. Check all wheel cylinders for cracked, cut, or torn boots

5. Pull back the lower edge of the boot carefully to check for fluid leakage (Figure 7)

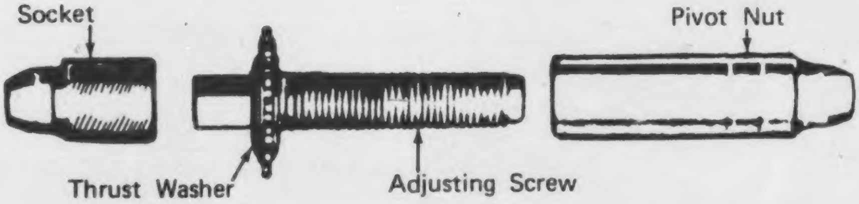
   (NOTE: Overhaul or replace cylinder if any fluid is present.)

FIGURE 7



6. Disassemble adjusting screw assembly (Figure 8)

FIGURE 8



JOB SHEET #4

7. Clean parts

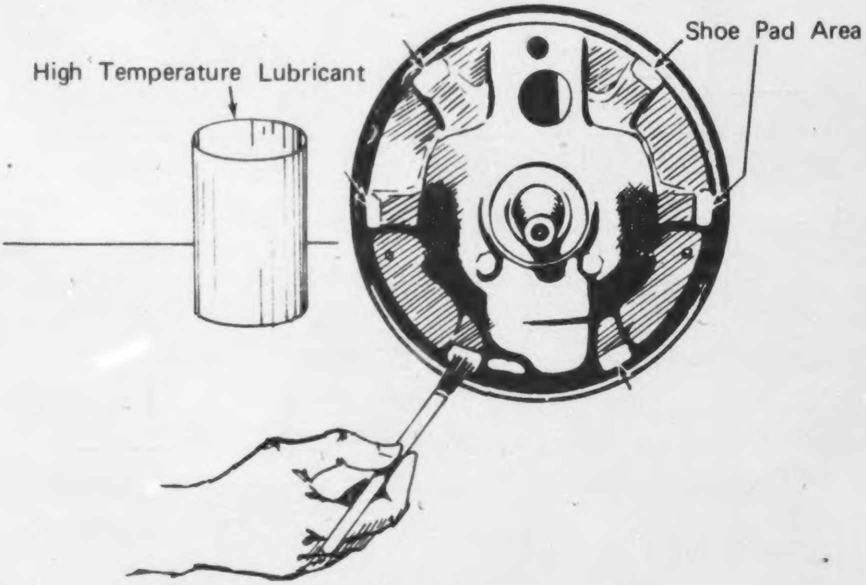
8. Lubricate the adjusting screw threads with high temperature lubricant

9. Reassemble parts

10. Turn the adjusting screw in as far as it will go

11. Apply a thin coat of lubricant to the raised shoe pads on the backing plate (Figure 9)

FIGURE 9



G. Replace brake shoes

1. Lay the replacement brake shoes in the same position as they are to be installed

   (NOTE: The primary shoe, the shoe with the shortest lining, goes to the front of the vehicle.)

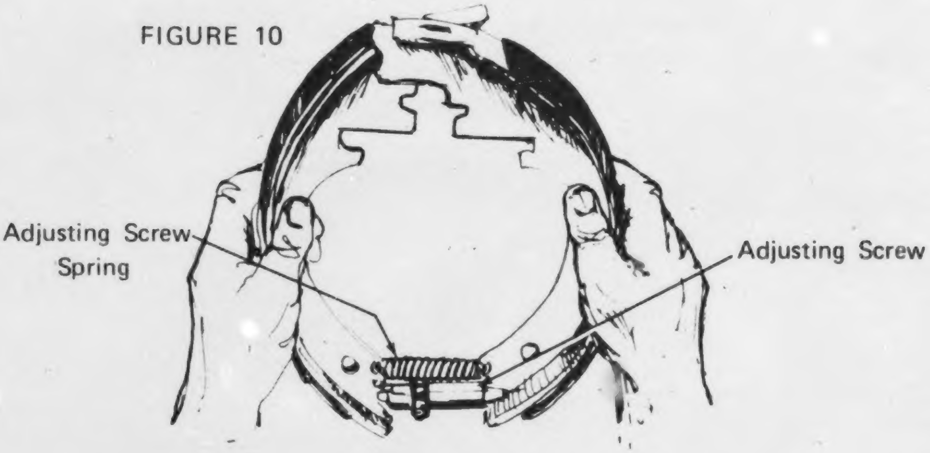
   (CAUTION: Make sure all parts are kept clean during reassembly. This is a MUST for safe brake work.)

2. Hook the brake shoe adjusting screw spring between the shoes

JOB SHEET #4

3. Overlap the anchor ends of the shoes; install the adjusting screw between the shoes (Figure 10)

FIGURE 10

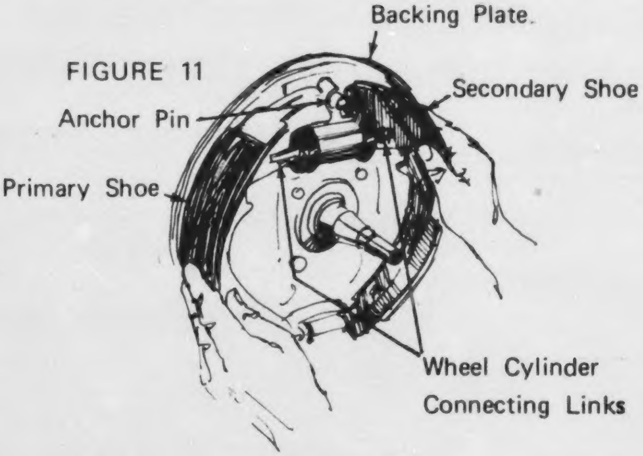

Adjusting Screw Spring
Adjusting Screw

(NOTE: Make sure the adjusting screw assembly is installed to align with the adjusting slot in the backing plate.)

4. Spread the anchor ends of the brake shoes to retain the adjusting screw and spring

5. Position the brake shoe assemblies on the backing plate so that the shoes engage the wheel cylinder connecting links (Figure 11)

FIGURE 11

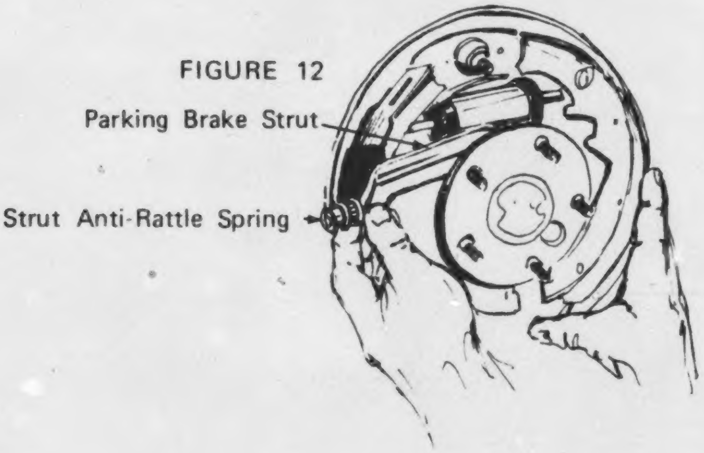

Backing Plate
Secondary Shoe
Anchor Pin
Primary Shoe
Wheel Cylinder Connecting Links

(NOTE: Make sure the primary brake shoe is positioned toward the front of the car and the adjusting screw assembly is installed correctly.)

JOB SHEET #4

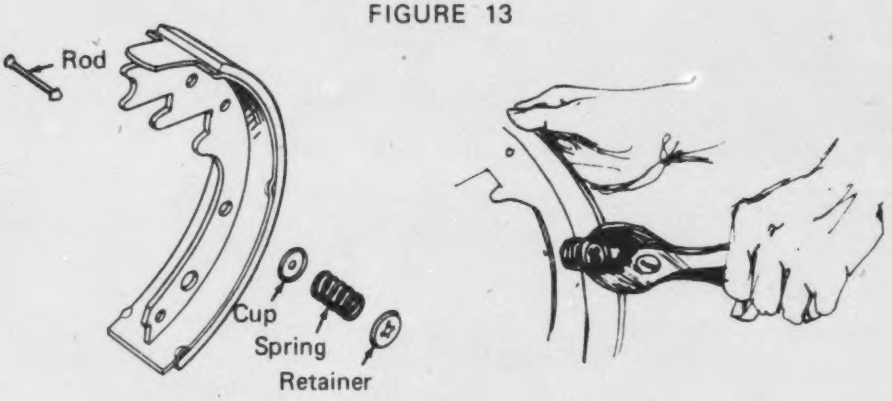
6. Spread the shoes slightly and install the parking brake strut and spring on rear brakes (Figure 12)

FIGURE 12


Parking Brake Strut
Strut Anti-Rattle Spring

7. Reinstall the brake shoe retaining or hold-down parts (Figure 13)

FIGURE 13


Rod
Cup
Spring
Retainer

(NOTE: Install self-adjusting mechanism if required.)

8. Replace brake shoe return springs

(NOTE: Make sure the brake shoe return springs are reinstalled correctly and the anchor end of spring is properly formed.)

JOB SHEET #4

9. Grasp the brake shoe assembly and move it back and forth slightly to make sure all parts are in place and correctly installed

(NOTE: Make preliminary brake shoe adjustment on self-adjusting brakes before installing brake drum.)

H. Replace the front brake drums

(NOTE: Make sure the drums are clean and have received the necessary service.)

I. Adjust the front wheel bearings

J. Install the nut lock and new cotter pin

K. Install grease cap and hub cap

L. Replace the rear brake drums

(NOTE: Make sure the drums are clean and have received the necessary service.)

M. Replace the rear drum retainer clips as required

N. Replace all wheels and tires

O. Torque lug bolts in sequence to manufacturer's specifications

P. Adjust all brakes

Q. Bleed brake system as required

R. Check brake pedal height and feel

S. Remove jack stands

T. Lower car to floor

U. Road test with instructor

BRAKE SYSTEM
UNIT I

JOB SHEET #5--REMOVE, RECONDITION, AND REPLACE A WHEEL CYLINDER

I. Tools and equipment

- A. Combination end wrenches, 5/16" - 3/4" (7 mm - 19 mm)
- B. Brake shoe removal tools
- C. Brake fluid
- D. Brake cylinder hone
- E. Lug wrench
- F. Channel lock pliers
- G. Diagonal side cutting pliers
- H. Sockets, 3/8" drive, 7/16" - 9/16" (10 mm - 14 mm)
- I. Ratchet, 3/8" drive
- J. Shop towels
- K. Crocus cloth
- L. Sockets, 3/8" drive, 6-point, 1/4" - 7/16" (6 mm - 11 mm)
- M. Electric drill
- N. Floor jack
- O. Jack stands
- P. Tubing wrenches, 3/8" - 5/8" (8 mm - 15 mm)
- Q. Torque wrench
- R. Brake bleeding tools as required

II. Procedure

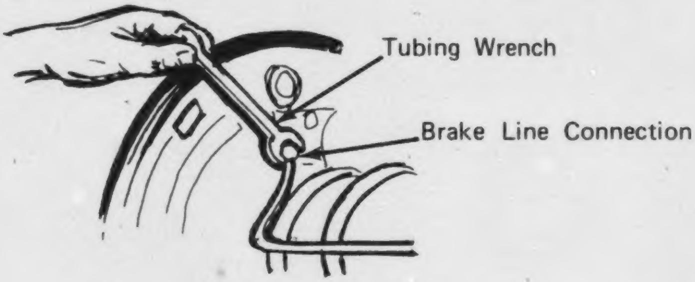
- A. Support vehicle on jack stands
- B. Remove tire and brake drum assembly
- C. Remove brake shoes

JOB SHEET #5

D. Disconnect the brake line or hose from the wheel cylinder (Figure 1)

(CAUTION: Use care to prevent twisting the line or connection. Disconnect hoses at the frame connection first.)

FIGURE 1


Tubing Wrench
Brake Line Connection

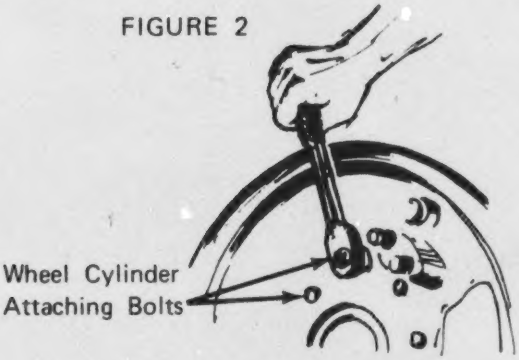
(NOTE: Cover the end of the hose or tube to prevent the entry of dirt.)

E. Inspect brake hoses

(NOTE: Replace if the hose cover is cracked or frayed.)

F. Remove the wheel cylinder attaching bolts (Figure 2)

FIGURE 2


Wheel Cylinder
Attaching Bolts

G. Remove the wheel cylinder from backing plate

H. Disassemble the wheel cylinder (Figure 3)

1. Remove the wheel cylinder links if used
2. Remove the wheel cylinder boots

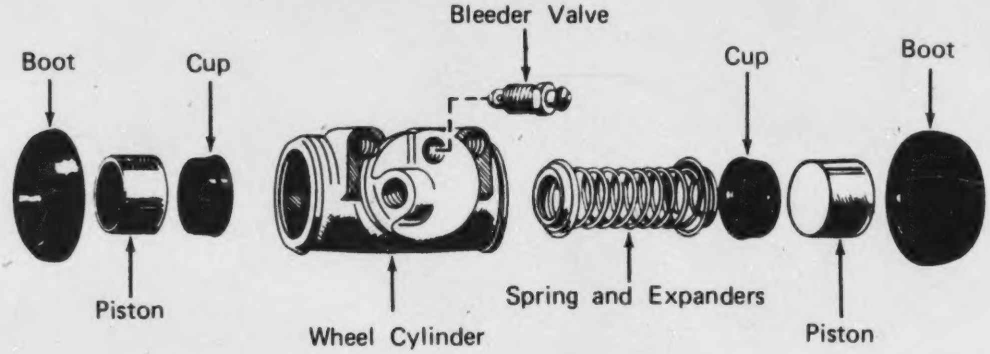
JOB SHEET #5

3. Push out the pistons, cups, and spring expanders

4. Remove the bleeder screw from the cylinder

   (NOTE: Use 6-point socket or box-end wrench for removal.)

FIGURE 3



I. Clean and service wheel cylinder

1. Clean all reusable metal parts

   (CAUTION: Always use clean brake fluid to clean any wheel cylinder parts. Never use mineral-base cleaning solvents such as gasoline, kerosene, carbon-tetrachloride, acetone, or paint thinner. These solvents deteriorate rubber parts.)

2. Inspect the pistons for scratches, scoring, or corrosion

3. Inspect the bleeder valve for defective threads or dirt

4. Inspect the cylinder bore of the wheel cylinder

5. Polish discolored or stained areas with crocus cloth by revolving the cylinder on the cloth supported by a finger

   (NOTE: If cylinder walls have deep scratches or scoring, they will have to be reconditioned with a cylinder hone.)

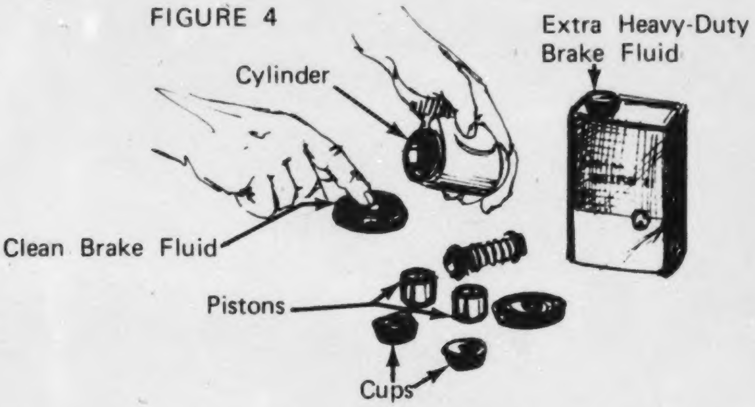
   (CAUTION: The cylinder bore should not be increased more than 0.002" [0.051 mm]. A cylinder that requires honing beyond the 0.002" [0.051 mm] limit should be replaced. See manufacturer's recommendations.)

JOB SHEET #5

J. Reassemble wheel cylinder

1. Coat the cups, pistons, and cylinder bore with clean brake fluid before reassembly (Figure 4)

FIGURE 4



2. Install the expanders on the spring as required

3. Install the spring and attached expanders into wheel cylinder

   (NOTE: Use care not to scratch the cylinder bore with the spring or expanders.)

4. Install the wheel cylinder cups with the lip toward the center of the cylinder

   (NOTE: Use care not to damage the cup lips during installation.)

5. Install the wheel cylinder pistons with the flat end toward the center of the cylinder

6. Install the wheel cylinder boots

7. Install the cylinder links

K. Install the wheel cylinder on the backing plate

L. Torque the bolts or anchor pin to manufacturer's specifications

M. Replace the brake line or hose to wheel cylinder

(NOTE: Use caution to avoid cross threading.)

N. Replace the brake shoe assembly

O. Replace the brake drum

P. Replace the wheels and tires

JOB SHEET #5

Q. Adjust brake shoes as required

R. Bleed the hydraulic system

S. Remove jack stands

T. Lower car to floor

U. Road test with instructor

BRAKE SYSTEM
UNIT I

JOB SHEET #6--REMOVE, RECONDITION, AND REPLACE A STANDARD MASTER CYLINDER

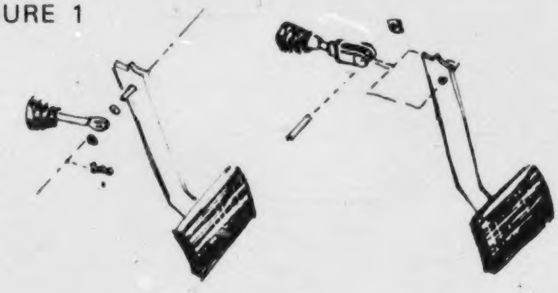
I. Tools and equipment

- A. Ratchet, 3/8" drive
- B. Sockets, 3/8" drive, 1/2" - 5/8" (12 mm - 15 mm)
- C. Extension, 3/8" drive, 6" (15 cm) long
- D. Combination end wrenches, 3/8" - 5/8" (8 mm - 15 mm)
- E. Diagonal side cutting pliers
- F. Adjustable end wrench, 10" (25 cm) long
- G. Brake fluid
- H. Brake cylinder hone
- I. Fender cover
- J. Tubing wrenches
- K. Brake bleeding tools as required
- L. Snap ring pliers

II. Procedure

- A. Raise the hood
- B. Place fender cover on left front fender
- C. Disconnect the master cylinder push rod from the brake pedal if necessary (Figure 1)

FIGURE 1



JOB SHEET #6

(NOTE: On most power brake units, the master cylinder can be removed without removing the vacuum cylinder from the car.)

D. Disconnect the hydraulic line at the master cylinder

(NOTE: Use a back-up wrench as required to avoid twisting the hydraulic line.)

E. Plug the disconnected line to avoid entrance of dirt

F. Disconnect the stop light wires from the stop light switch if required

G. Remove the bolts that hold the master cylinder in place

H. Lift the cylinder out of the vehicle

(NOTE: Use care to avoid spilling any brake fluid on the exterior paint.)

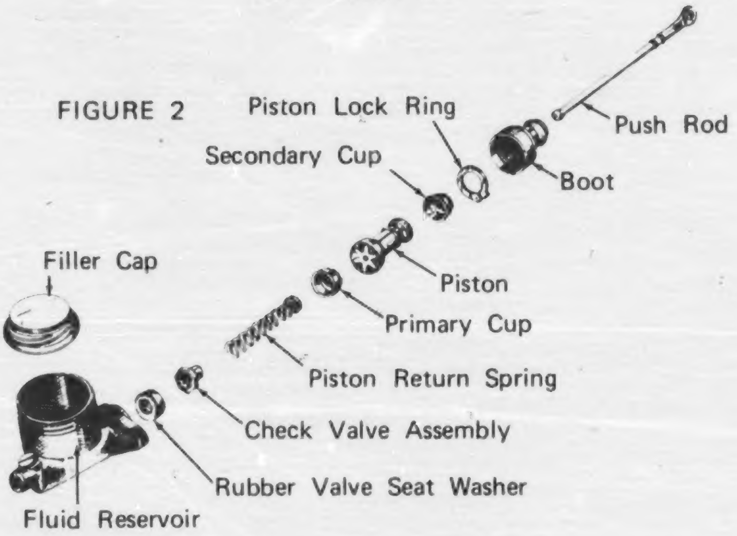
I. Disassemble master cylinder

(NOTE: See Figure 2 on following page.)

1. Brush off external dirt before disassembly
2. Remove filler cap and gasket
3. Pour out any brake fluid that remains in cylinder or reservoir
4. Pull back or remove the boot to expose the piston retaining ring
5. Remove the piston retaining ring from the master cylinder bore
6. Remove the piston
7. Remove the primary cup, spring, and check valve from bore of cylinder
8. Remove the rubber valve seat washer from cylinder bore

JOB SHEET #6

FIGURE 2

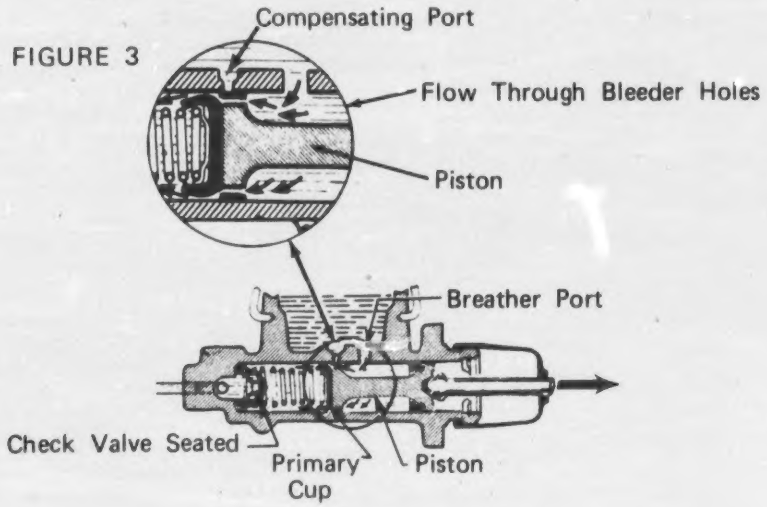

Piston Lock Ring
Push Rod
Secondary Cup
Boot
Filler Cap
Piston
Primary Cup
Piston Return Spring
Check Valve Assembly
Rubber Valve Seat Washer
Fluid Reservoir

J. Clean and inspect master cylinder parts

1. Clean all parts thoroughly with warm water and detergent
2. Inspect the master cylinder body for cracks, scores, or scratches
3. Recondition master cylinder bore with a fine grit cylinder hone

   (CAUTION: Do not increase cylinder bore more than 0.002" [0.051 mm].)
4. Rinse the cylinder with warm water and detergent
5. Clean the compensating port and breather port (Figure 3)

FIGURE 3


Compensating Port
Flow Through Bleeder Holes
Piston
Breather Port
Check Valve Seated
Primary Cup
Piston

JOB SHEET #6

(CAUTION: Do not enlarge the compensating port while cleaning it.)

6. Check piston, spring, check valve, and seats for a reusable condition and replace as necessary

7. Check filler cap to see that vent holes are open and baffle is in place

K. Reassemble the master cylinder

   1. Lubricate the master cylinder bore and all internal rubber parts with clean brake fluid

   2. Install the rubber washer against the shoulder inside the master cylinder bore

   3. Install the check valve on the large end of the spring

   4. Install the spring and check valve assembly with the check valve end first into the bore

   5. Install the primary cup over the end of the spring with the concave side toward the spring

   6. Install the piston into the bore

   7. Install the piston retaining ring while compressing the piston and spring

   8. Install the boot and push rod if required

   9. Bleed air from the master cylinder

      a. Fill the master cylinder reservoir with extra heavy duty brake fluid

      b. Push the piston in

      c. Place a finger over the outlet holes

      d. Release the piston

      e. Repeat this operation until a solid stream of fluid is emitted from the outlet

JOB SHEET #6

L. Place master cylinder into position; tighten bolts

M. Install hydraulic brake line and tighten

(NOTE: Use care to avoid cross threading.)

N. Install master cylinder push rod pin

(NOTE: Check brake pedal free travel; adjust if required.)

O. Fill the master cylinder with clean brake fluid

P. Reconnect the stop light wires if required

Q. Bleed the hydraulic system

BRAKE SYSTEM
UNIT I

JOB SHEET #7--REMOVE, RECONDITION, AND REPLACE A TANDEM MASTER CYLINDER

I. Tools and equipment

A. Ratchet, 3/8" drive

B. Sockets, 3/8" drive, 1/2" - 5/8" (12 mm - 15 mm)

C. Extension, 3/8" drive, 6" (15 cm) long

D. Combination end wrenches, 3/8" - 5/8" (8 mm - 15 mm)

E. Diagonal side cutting pliers

F. Adjustable end wrench, 10" (25 cm) long

G. Brake fluid

H. Brake cylinder hone

I. Fender cover

J. Outlet plugs

K. Snap ring pliers

L. Hydraulic line plugs

M. Brake bleeding tools as required

N. Tubing wrenches

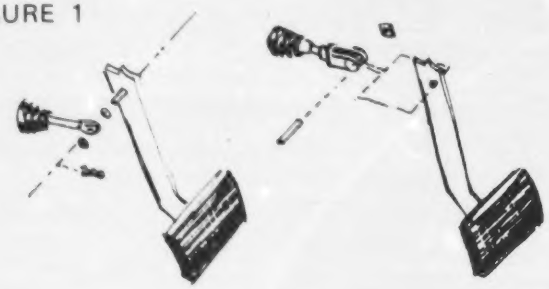
II. Procedure

A. Raise the hood

B. Place fender cover on left front fender

C. Disconnect the master cylinder push rod from the brake pedal if necessary (Figure 1)

FIGURE 1



JOB SHEET #7

(NOTE: On most power brake units, the master cylinder can be removed without removing the vacuum cylinder from the car.)

D. Disconnect the hydraulic lines at the master cylinder

(NOTE: Use a backup wrench as required to avoid twisting the hydraulic line.)

E. Plug the disconnected line to avoid entrance of dirt

F. Remove the master cylinder mounting bolts

G. Remove the master cylinder from the vehicle

(NOTE: Use care to avoid spilling any brake fluid on the exterior paint.)

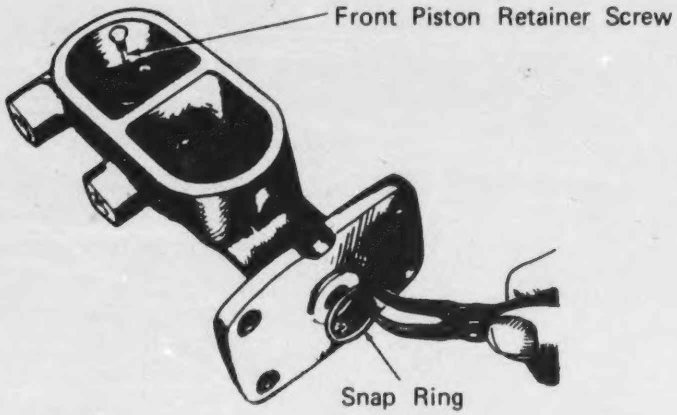
H. Disassemble master cylinder

1. Brush off external dirt before disassembly
2. Remove reservoir cover and diaphragm
3. Empty brake fluid from reservoirs
4. Place the master cylinder in a vise for support

   (CAUTION: Do not overtighten the vise.)

5. Remove the secondary piston stop screw (Figure 2)
6. Remove the primary piston retainer snap ring (Figure 2)

FIGURE 2



JOB SHEET #7

7. Remove the primary piston assembly

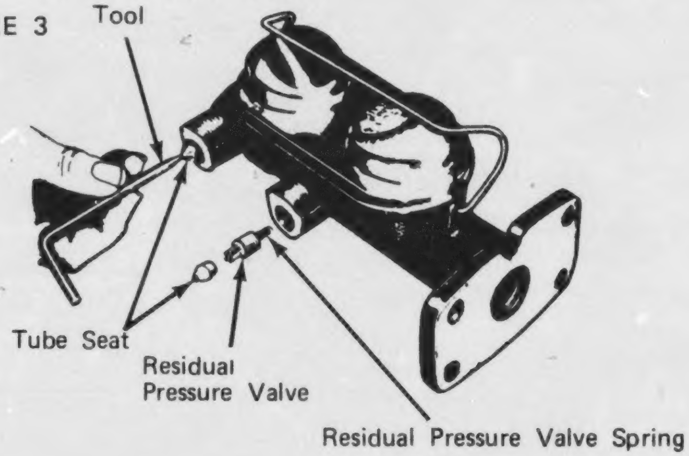
8. Remove the secondary piston by tamping the open end of the master cylinder on the bench

   (NOTE: If the secondary piston is stuck in the bore, air pressure may be used to force the piston out of the cylinder.)

   (CAUTION: When using air pressure to remove the piston, place the open end of the cylinder down against the bench.)

9. Remove tube seats on models that have residual pressure check valves behind them (Figure 3)

FIGURE 3



(CAUTION: Disc brake models have a residual check valve on the drum brake line but not on the disc brake line.)

I. Clean and inspect parts

1. Wash the cylinder bore with warm water and detergent

2. Inspect the cylinder bore for scoring or pitting

   (NOTE: The cylinder bore may be reconditioned with a hone if the diameter is not increased more than 0.002" [0.051 mm]. If more is required, the cylinder must be replaced.)

3. Inspect pistons for scoring or corrosion; replace as necessary

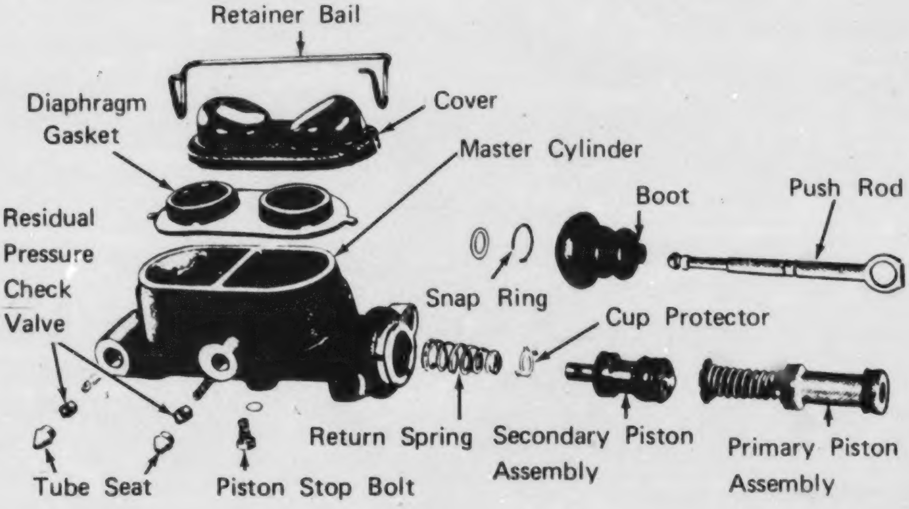
   (NOTE: Replace all cups and seals when reconditioning a master cylinder.)

JOB SHEET #7

J. Reassemble the master cylinder

(NOTE: Dip all internal parts in clean brake fluid before they are assembled. See Figure 4.)

FIGURE 4


Retainer Bail
Diaphragm Gasket
Cover
Master Cylinder
Boot
Push Rod
Residual Pressure Check Valve
Snap Ring
Cup Protector
Return Spring
Secondary Piston Assembly
Primary Piston Assembly
Tube Seat
Piston Stop Bolt

1. Assemble cups and seals on the secondary piston
2. Install the secondary piston return spring and secondary piston into the cylinder

   (NOTE: Use care when installing the lip seals in the cylinder to avoid damage to the seal.)
3. Install the primary piston assembly in the cylinder
4. Hold the primary piston in a seated position; install the piston retainer snap ring
5. Install the secondary piston stop screw

JOB SHEET #7

6. Install new residual check valves in tube connection bore if so equipped

7. Install new tubing seats

   (NOTE: Be sure the seats are pressed in straight.)

K. Bleed the master cylinder before installation

   1. Clamp the master cylinder in a vise with the reservoir level

   2. Fill both reservoirs with brake fluid

   3. Push the primary piston in slowly until it bottoms

      (NOTE: On a master cylinder that does not have a push rod, use a rod with a smooth, round end to pump the cylinder.)

   4. Place your fingers over the outlet holes while you let the piston return slowly

   5. Continue to operate the pistons until the bubbles disappear from the fluid emitted from the outlet holes

   6. Fill the reservoirs to the proper level

   7. Install the diaphragm gasket and cover

L. Install the master cylinder on the vehicle

   1. Place a new mounting gasket on the master cylinder

   2. Secure the cylinder to the dash panel or power brake unit with the attaching bolts

   3. Connect the push rod to the brake pedal on manual brakes if necessary

   4. Remove covers from hydraulic lines

   5. Connect the hydraulic lines to the cylinder

M. Bleed the brake hydraulic system

JOB SHEET #7

N. Check master cylinder piston end play

  1. Pump the brake pedal several times rapidly and then hold firm pressure on the pedal

  2. Release the pressure on the pedal while observing for a geyser in each reservoir from fluid escaping from the compensating part

     (NOTE: If a movement of fluid is not detected in the reservoirs, it indicates that the master cylinder pistons are not returning properly to their seats. The problem will have to be corrected before the brakes will operate properly.)

O. Fill master cylinder reservoirs to the proper level

P. Replace the reservoir cover and diaphragm gasket

Q. Road test the vehicle to test proper brake operation

R. Check for any fluid leaks after road test

BRAKE SYSTEM
UNIT I

TEST

1. Write the purpose of the brake system.

2. Match the terms on the right to the correct definition.

_____a. Cylinder that produces or is controlled by the motion of fluid

_____b. Refers to the removal of air from the hydraulic brake system

_____c. Special fluid used in hydraulic brake systems

_____d. Refers to fluid in motion

_____e. Hydraulic cylinder used to force the brake fluid to the individual wheel cylinders when applying the brakes

_____f. High pressure line used to carry the brake fluid from the master cylinder to the wheel cylinders

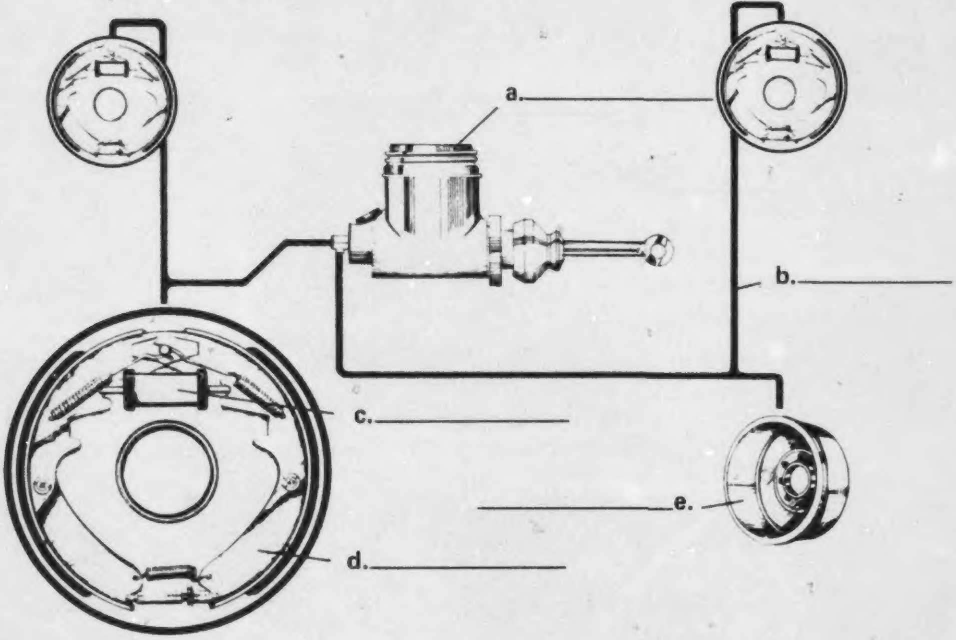
_____g. Hydraulic cylinder which is actuated by hydraulic pressure to force the brake lining into contact with the brake drum

_____h. That part of the brake assembly to which the brake lining is attached

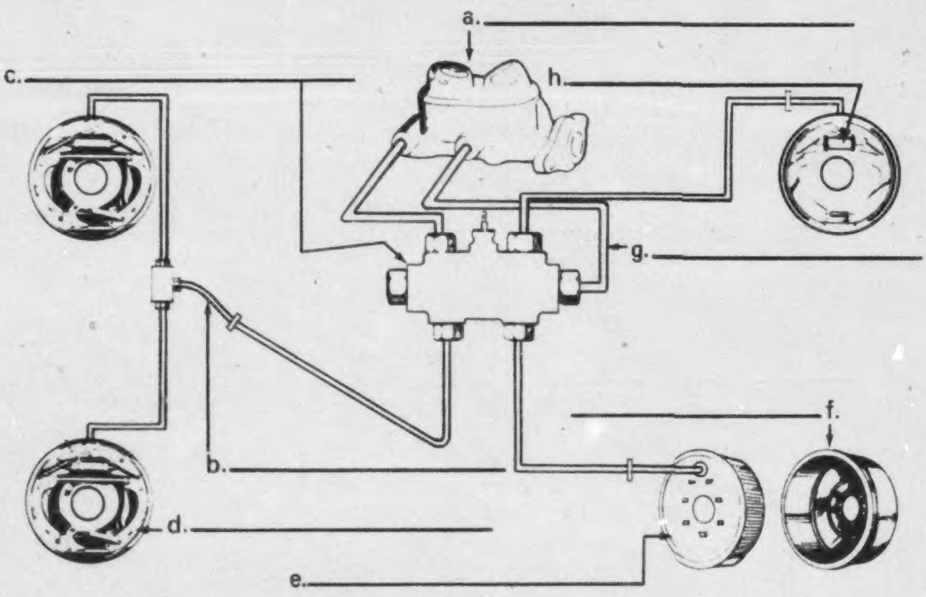
_____i. Cast iron or aluminum housing that rotates around the brake assembly providing a smooth surface for the brake shoes to contact and exert braking action

1. Brake fluid
2. Hydraulic
3. Hydraulic cylinder
4. Bleeding the brakes
5. Wheel cylinder
6. Master cylinder
7. Brake drum
8. Brake shoe
9. Brake line

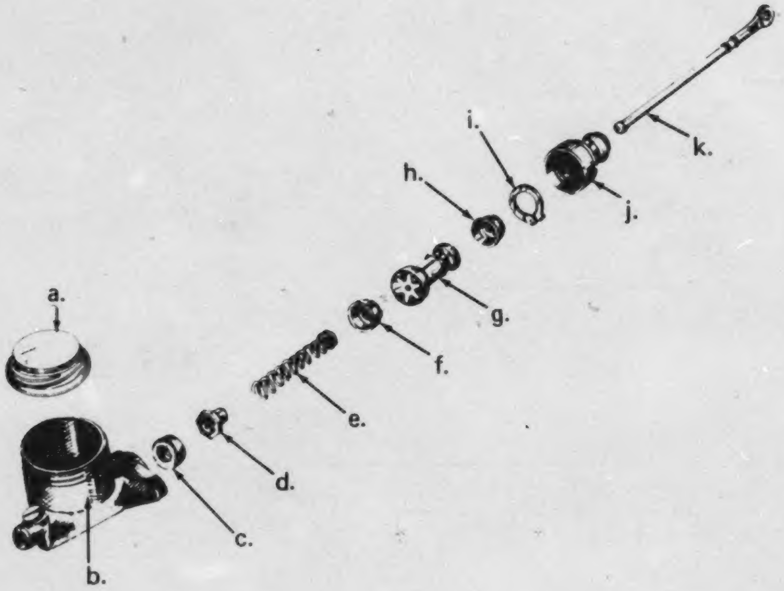
3. Identify the components of the standard brake system in the diagram below by writing the correct names in the blanks provided.



4. Identify the components of the tandem or dual brake system in the diagram below by writing the correct names in the blanks provided.



5. Identify the parts of the standard master cylinder in the diagram below by writing the correct names in the blanks provided.



a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

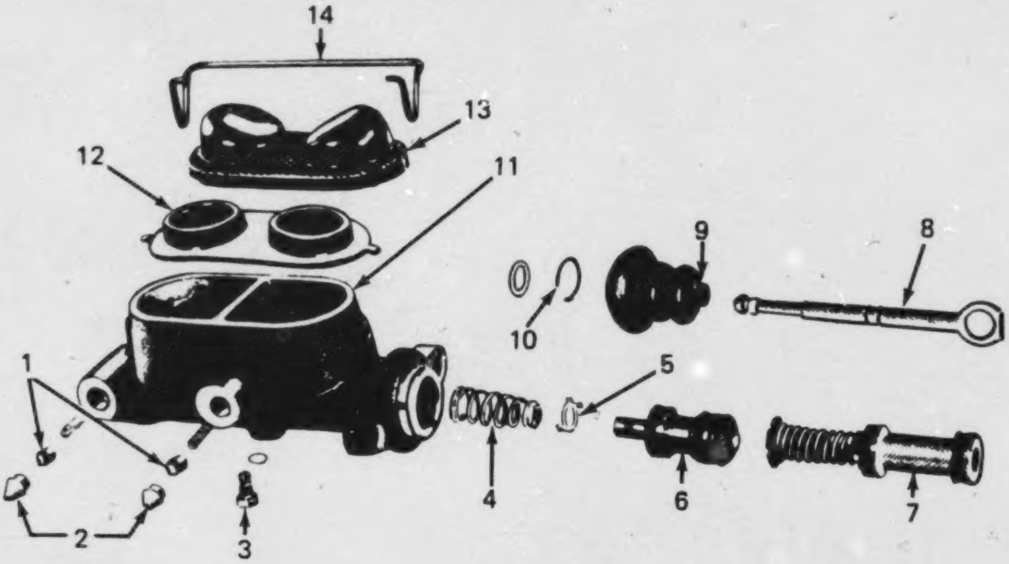
h. ______________________________

i. ______________________________

j. ______________________________

k. ______________________________

6. Identify the parts of the tandem master cylinder in the diagram below by writing the correct number in the blanks provided.



______a. Push rod

______b. Cover

______c. Residual pressure check valve

______d. Diaphragm gasket

______e. Tube seat

______f. Return spring

______g. Secondary piston assembly

______h. Retainer bail

______i. Boot

______j. Cup protector

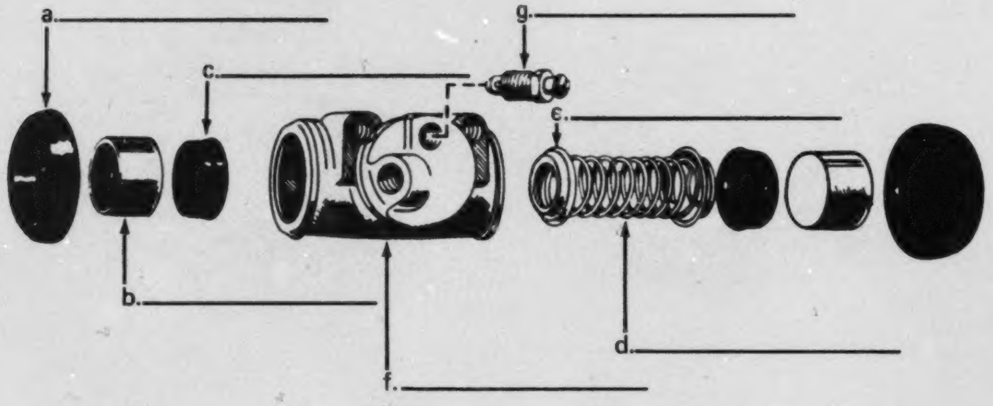
______k. Primary piston assembly

______l. Master cylinder

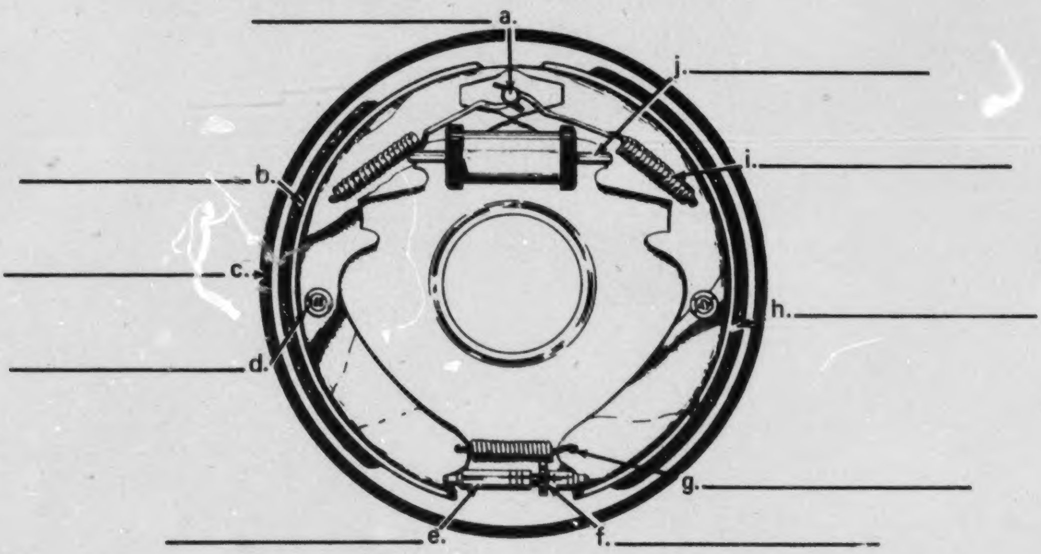
______m. Piston stop bolt

______n. Snap ring

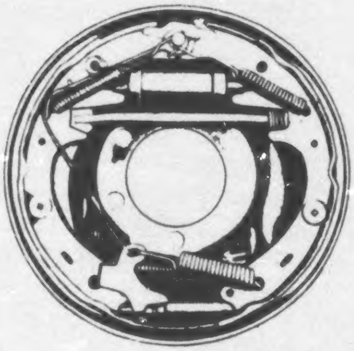
7. Identify the parts of the wheel cylinder in the diagram below by writing the correct names in the blanks provided.



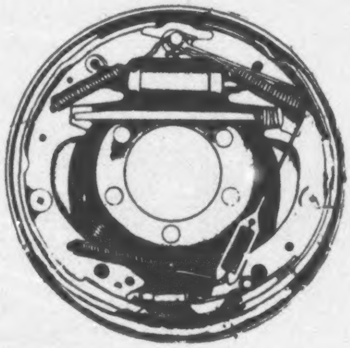
8. Identify the parts of the standard brake assembly in the diagram below by writing the correct names in the blanks provided.



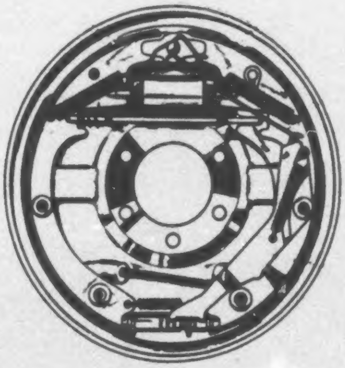
9. Identify the types of self-adjusting brake systems in the diagrams below by writing the correct names in the blanks provided.



a.______________________________



b.______________________________



c.______________________________

10. Describe brake operation.

a. As the brake pedal is depressed

b. As the brake pedal is released

11. Demonstrate the ability to:

    a. Adjust brake shoes.

    b. Bleed the hydraulic system.

    c. Remove, inspect, and replace brake drums.

    d. Remove and replace brake shoes.

    e. Remove, recondition, and replace a wheel cylinder.

    f. Remove, recondition, and replace a master cylinder.

    g. Remove, recondition, and replace a tandem master cylinder.

    (NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

BRAKE SYSTEM
UNIT I

ANSWERS TO TEST

1. To provide a method of slowing or stopping the car by the driver

2. a. 3
   b. 4
   c. 1
   d. 2
   e. 6
   f. 9
   g. 5
   h. 8
   i. 7

3. a. Master cylinder
   b. Brake line
   c. Wheel cylinder
   d. Brake shoe
   e. Brake drum

4. a. Tandem or dual master cylinder
   b. Brake flex hose
   c. Pressure differential valve and brake warning light switch
   d. Brake shoe
   e. Backing plate
   f. Brake drum
   g. Brake line
   h. Wheel cylinder

5. a. Filler cap
   b. Fluid reservoir
   c. Rubber valve seat washer
   d. Residual pressure check valve assembly

   e. Piston return spring
   f. Primary cup
   g. Piston
   h. Secondary cup
   i. Piston lock ring
   j. Boot
   k. Push rod

6. a. 8
   b. 13
   c. 1
   d. 12
   e. 2
   f. 4
   g. 6
   h. 14
   i. 9
   j. 5
   k. 7
   l. 11
   m. 3
   n. 10

7. a. Boot
   b. Piston
   c. Cup expander
   d. Spring
   e. Expander
   f. Cylinder
   g. Bleeder screw

8. a. Anchor pin
    b. Primary brake shoe and lining
    c. Backing plate
    d. Brake shoe retainer
    e. Adjusting screw
    f. Star wheel
    g. Adjusting screw spring
    h. Secondary brake shoe and lining
    i. Return spring
    j. Connecting link

9. a. Cable pull, early type
    b. Cable pull, late type
    c. Lever type

10. Description should include:

    a. As the brake pedal is depressed

        1) The master cylinder forces brake fluid through the check valve into the brake lines

        2) The fluid travels through the brake lines to the wheel cylinders

        3) The force of brake fluid by the master cylinder causes the wheel cylinder cups and pistons to move outward

        4) The movement caused by the wheel cylinder pistons forces the brake shoe and lining to make contact with the brake drum

        5) The force of the fluid and the contact of the brake lining with the brake drum cause the vehicle to slow or stop

    b. As the brake pedal is released--The return springs pull the brake shoes back to the stop position, forcing the brake fluid to return to the master cylinder reservoir

11. Performance skills will be evaluated to the satisfaction of the instructor.

POWER DISC BRAKES
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the components of the various disc brake systems and match the components to their functions. The student should be able to discuss the operation of each type of power booster and demonstrate the ability to test and repair a disc brake system. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with power disc brakes to the correct definitions.
2. Identify the major components of the disc brake system.
3. Match the components of the disc brake system to the correct functions.
4. List the types of disc brake calipers.
5. Identify the parts of a floating caliper disc brake.
6. List good characteristics of disc brakes.
7. Discuss reasons that disc brakes may require power booster units.
8. List sources of energy for power boosters.
9. List the types of vacuum operated power boosters.
10. Identify the major parts of a vacuum operated power booster.
11. Identify the major parts of the hydro-boost power booster.
12. Discuss briefly the operation of the vacuum suspended power booster.
13. Discuss briefly the operation of the atmospheric suspended power booster.
14. Discuss briefly the operation of the hydro-boost power booster.

15. List the requirements of super heavy-duty brake fluid.

16. Discuss conditions that are considered normal and are not indications that the master cylinder needs service.

17. Identify the parts of the parking brake system on four wheel disc brakes.

18. Demonstrate the ability to:

    a. Test the hydraulic system.

    b. Test the vacuum power booster.

    c. Repair a sliding caliper disc brake.

    d. Check disc runout and thickness.

POWER DISC BRAKES
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information sheet.
- F. Demonstrate and discuss procedures outlined in the job sheets.
- G. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Demonstrate the ability to accomplish the procedures outlined in the job sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
    1. TM 1--Major Components of the Disc Brake System
    2. TM 2--Operation of the Pressure Differential Valve
    3. TM 3--Operation of the Proportioning Valve

4. TM 4--Operation of the Metering Valve
5. TM 5--Types of Disc Brake Calipers
6. TM 6--Parts of a Floating Caliper Disc Brake
7. TM 7--Types of Vacuum Operated Power Boosters
8. TM 8--Major Parts of a Vacuum Operated Power Booster
9. TM 9--Major Parts of a Hydro-Boost Power Booster
10. TM 10--Operation of the Vacuum Suspended Power Booster
11. TM 11--Parts of Parking Brake on Four Wheel Disc Brake System: Drum Type

D. Job sheets

1. Job Sheet #1--Test the Hydraulic System
2. Job Sheet #2--Test the Vacuum Power Booster
3. Job Sheet #3--Repair a Sliding Caliper Disc Brake
4. Job Sheet #4--Check Disc Runout and Thickness

E. Test

F. Answers to test

II. References:

A. Toboldt, William K., and Purvis, Jud. *Motor Service's Automotive Encyclopedia.* Homewood, Illinois: Goodheart-Willcox Co., 1965.

B. Ellinger, Herbert E. *Automechanics.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1972.

C. Stockel, Martin W. *Auto Mechanics Fundamentals.* South Holland, Illinois: Goodheart-Willcox Co., 1969.

D. *Ford Service Manual.* Dearborn, Michigan: Ford Motor Co., 1971.

E. *Chevrolet Service Manual.* Detroit, Michigan: Chevrolet Motor Div./General Motors Corp., 1973.

F. *Plymouth Service Manual.* Detroit, Michigan: Chrysler-Plymouth Div./Chrysler Corp., 1975.

POWER DISC BRAKES
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Disc brakes--Brake system utilizing a caliper which compresses brake shoes against a circular disc

B. Friction--Resistance to relative movement between two bodies in contact

C. Brake fade--Condition caused by heat or moisture that decreases friction and the braking power of the system

D. Servo action--Larger action that results from a smaller input action

EXAMPLE: The self-energizing effect of drum type brakes

E. Power booster--Vacuum or hydraulic operated unit that is designed to assist the driver when applying the brakes

F. Hydro-boost--Power assist unit operated by hydraulic pressure from the power steering pump

G. Manifold vacuum--Pressure lower than atmospheric pressure developed in the engine intake manifold and cylinders by the movement of the pistons in the cylinders

(NOTE: This low pressure is used to operate the power booster by applying vacuum to one side of a diaphragm and atmospheric pressure to the other.)

H. Inboard shoe--Shoe next to the single piston in the caliper and on the vehicle frame side of the brake disc

I. Outboard shoe--Shoe opposite the caliper piston and outside the brake disc

J. DOT--Department of Transportation; federal government agency whose function is to set standards for safety items on motor vehicles

II. Major components of the disc brake system (Transparency 1)

A. Master cylinder

B. Pressure differential valve

INFORMATION SHEET

   C. Proportioning valve
   D. Metering valve
   E. Front disc or rotor assembly
   F. Caliper assembly
   G. Power booster unit
   H. Rear drum or disc brake assembly

III. Disc brake components and their functions

   A. Master cylinder--Forces brake fluid into all wheel cylinders when brakes are applied

   B. Pressure differential valve--Senses unbalanced pressure between the front and rear brake systems and causes the warning light to shine (Transparency 2)

   C. Proportioning valve--Regulates rear brake system hydraulic pressure to prevent premature rear wheel skid on emergency stops (Transparency 3)

   D. Metering valve--Regulates the hydraulic pressure to the front disc brakes in the 3 to 135 psi range to allow the rear drum brake shoes to begin brake action to prevent locking of the front brakes especially on icy or slick surfaces (Transparency 4)

   E. Disc or rotor assembly--Provides a friction surface for the lining to exert a force resisting the rotation of the wheel

   F. Caliper assembly--Contains friction linings and a hydraulic piston to supply force on the linings to stop the rotor

   G. Power booster unit--Assists the driver in applying the brakes

IV. Types of disc brake calipers (Transparency 5)

   A. Fixed
   B. Floating
   C. Sliding

V. Parts of a floating caliper disc brake (Transparency 6)

   A. Disc and hub assembly
   B. Shoe and lining

INFORMATION SHEET

- C. Caliper adapter
- D. Caliper
- E. Piston
- F. Seal
- G. Boot
- H. Mounting bolts
- I. Bleeder screw
- J. Bushings

VI. Characteristics of disc brakes

- A. Fade resistant
- B. More even stopping of vehicle
- C. More efficient in adverse conditions

  (NOTE: Moisture does not affect the braking efficiency of disc brakes as much as drum brakes.)
- D. Simple in design for easier maintenance
- E. Better adapted to heavier vehicles

  (NOTE: Power disc brakes are made stronger and can withstand higher operating temperatures.)

VII. Reasons disc brakes may require power booster units

- A. Disc brake shoes have no servo action

  (NOTE: They require 4 to 5 times more applied pressure than drum brakes.)
- B. Disc shoe linings have less contact surface than drum brake shoes

VIII. Sources of energy used for power boosters

- A. Engine vacuum

  (NOTE: Vacuum is taken from the engine at the intake manifold connection.)
- B. Hydraulic pressure

  (NOTE: Hydraulic pressure is obtained from the power steering pump.)

INFORMATION SHEET

IX. Types of vacuum operated power boosters (Transparency 7)

   A. Vacuum suspended

   B. Atmospheric suspended

X. Major parts of a vacuum operated power booster (Transparency 8)

   A. Vacuum check valve

   B. Power piston

   C. Power piston return spring

   D. Diaphragm and valve body plate

   E. Floating control valve

   F. Brake pedal push rod

   G. Master cylinder push rod

   H. Front housing

   I. Rear housing

XI. Major parts of the hydro-boost power booster (Transparency 9)

   A. Input rod

   B. Control valve

   C. Boost piston

   D. Output rod

   E. Accumulator

   F. Accumulator control valve

   G. Control valve reaction lever

   H. Boost pressure chamber

XII. Operation of the vacuum suspended power booster (Transparency 10)

   A. In the at-rest position, vacuum is on both sides of the diaphragm

INFORMATION SHEET

B. As the brake pedal is applied, the pedal push rod actuates the control valve and allows atmospheric pressure to enter the front side of the diaphragm which assists the driver in applying force on the master cylinder piston

C. The amount of force applied by the driver controls the amount of atmospheric pressure that can enter the chamber to control braking effort

(NOTE: Sufficient vacuum is contained in the unit to provide several applications with the engine off.)

XIII. Operation of the atmospheric suspended power booster

A. In the at-rest position, atmospheric pressure is on both sides of the diaphragm

B. As the brake pedal is applied, the pedal push rod actuates the control valve which directs a controlled amount of vacuum to the back side of the diaphragm while the atmospheric pressure on the front side assists the driver in applying the brakes

C. The force applied by the driver controls the amount of vacuum exerted in the chamber to control braking effort

(NOTE: A vacuum tank outside the unit is used for reserve vacuum.)

XIV. Operation of the hydro-boost power booster

A. As the brake pedal is depressed, it moves the pedal rod and initiates movement of the control valve and allows fluid pressure from the power steering pump to enter the boost chamber to provide force on the boost piston to assist the driver in applying the brakes

B. Additional movement of the brake pedal will restrict fluid flow between the power steering pump and steering gear causing the power steering pump to increase its pressure for more power assist if needed

(NOTE: Reserve pressure for stopping with the engine off is contained in the accumulator.)

(CAUTION: Do not attempt to make repairs on the hydro-boost unit because an extremely strong spring in the accumulator is potentially dangerous.)

XV. Requirements of super heavy-duty brake fluid

(NOTE: Fluid used in disc brake systems must conform to DOT Code #3 as a minimum quality fluid.)

A. High boiling point

(NOTE: The fluid must not vaporize at temperatures lower than 550°F [287°C].)

INFORMATION SHEET

B. Low freezing point

(NOTE: The fluid must not freeze at lowest operating temperatures.)

C. Consistent viscosity

(NOTE: Fluid must be free flowing at all temperatures.)

D. Noncorrosive

(NOTE: The brake fluid must not attack metal or rubber parts.)

E. Water tolerance

(NOTE: The fluid must be able to absorb and retain moisture that enters the system.)

F. Lubricating ability

(NOTE: The fluid must lubricate pistons and seals to reduce wear and internal friction.)

XVI. Conditions that are considered normal and are not indications that the master cylinder needs service

A. Unequal brake fluid levels in master cylinder reservoir--This condition is caused by displacement of fluid from the reservoir into the calipers to compensate for normal lining wear

B. Momentary or slight squirt of brake fluid from one or both master cylinder reservoir chambers upon application of the brake pedal--This is caused by the fluid displacement through the cylinder compensating ports as the piston moves forward in the bore

C. Slight turbulence in the reservoir fluid occurring when the brake pedal is released--This is the result of brake returning from the releasing wheel cylinders

D. A trace of brake fluid on the power booster housing below the master cylinder mounting flange--Results from the lubricating action of the master cylinder wiping seal

XVII. Parts of a parking brake system on four wheel disc brakes (Transparency 11)

A. Parking brake shoes

B. Shoe hold-down spring assembly

C. Adjuster assembly

INFORMATION SHEET

D. Parking brake adapter

E. Shoe return springs

F. Actuating lever and shaft

G. Shoe actuator and cam

H. Parking brake drum and disc assembly

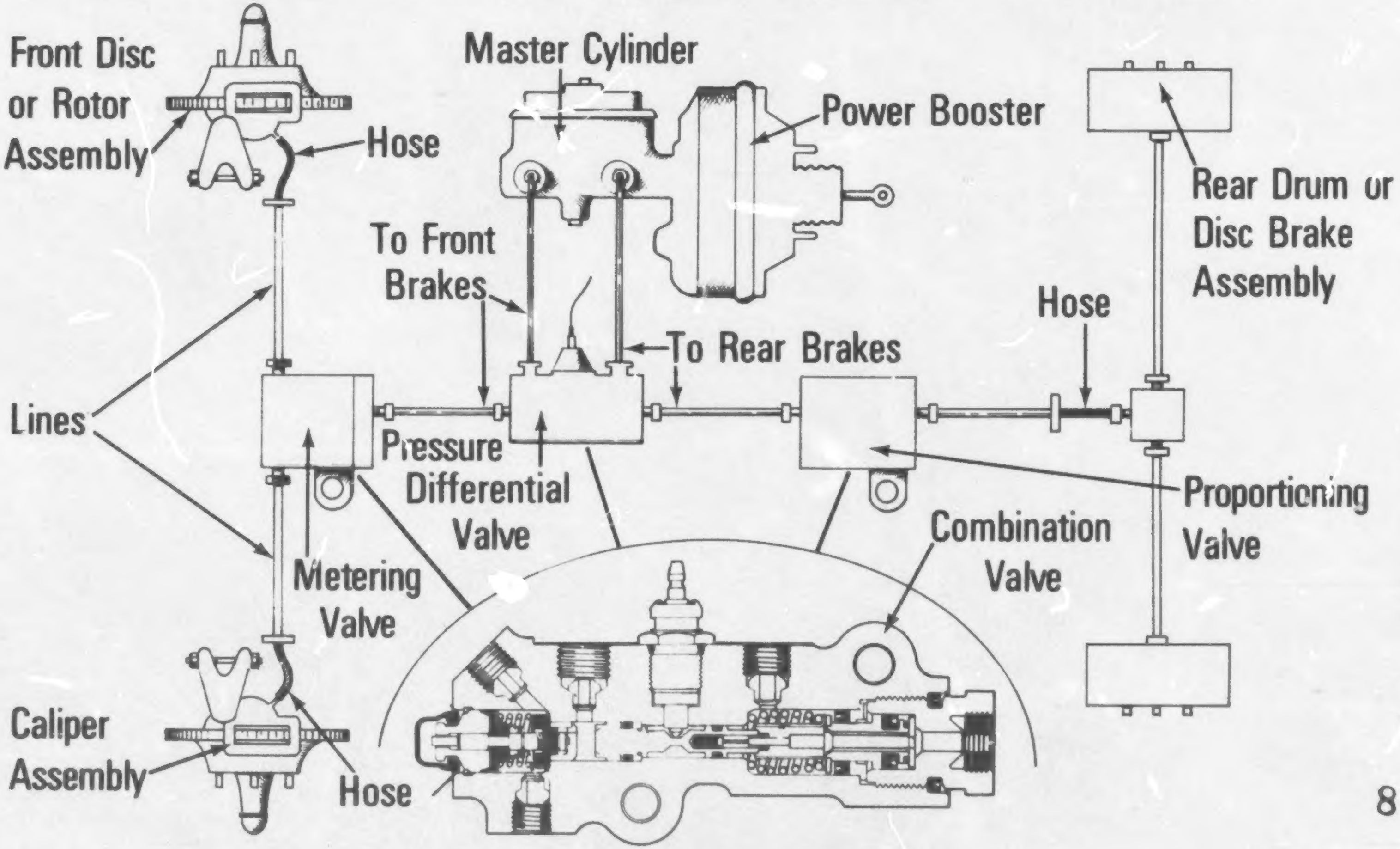
I. Parking brake cable

J. Splash shield and support plate

K. Shoe hold-down nails

Major Components of the Disc Brake System

(Note: The Pressure Differential, Proportioning, and Metering Valves are Usually Contained in One Housing and Known as a Combination Valve.)


Front Disc or Rotor Assembly
Hose
Master Cylinder
Power Booster
Rear Drum or Disc Brake Assembly
To Front Brakes
Hose
To Rear Brakes
Lines
Pressure Differential Valve
Proportioning Valve
Combination Valve
Metering Valve
Caliper Assembly
Hose

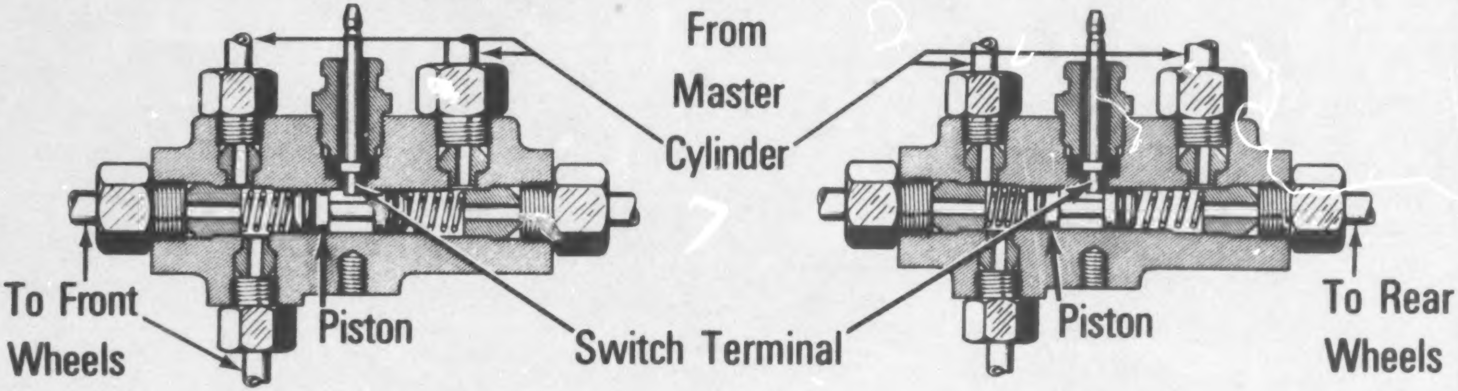
TM 1

AM I - 93-E

Operation of the Pressure Differential Valve

Valve in Normal Position

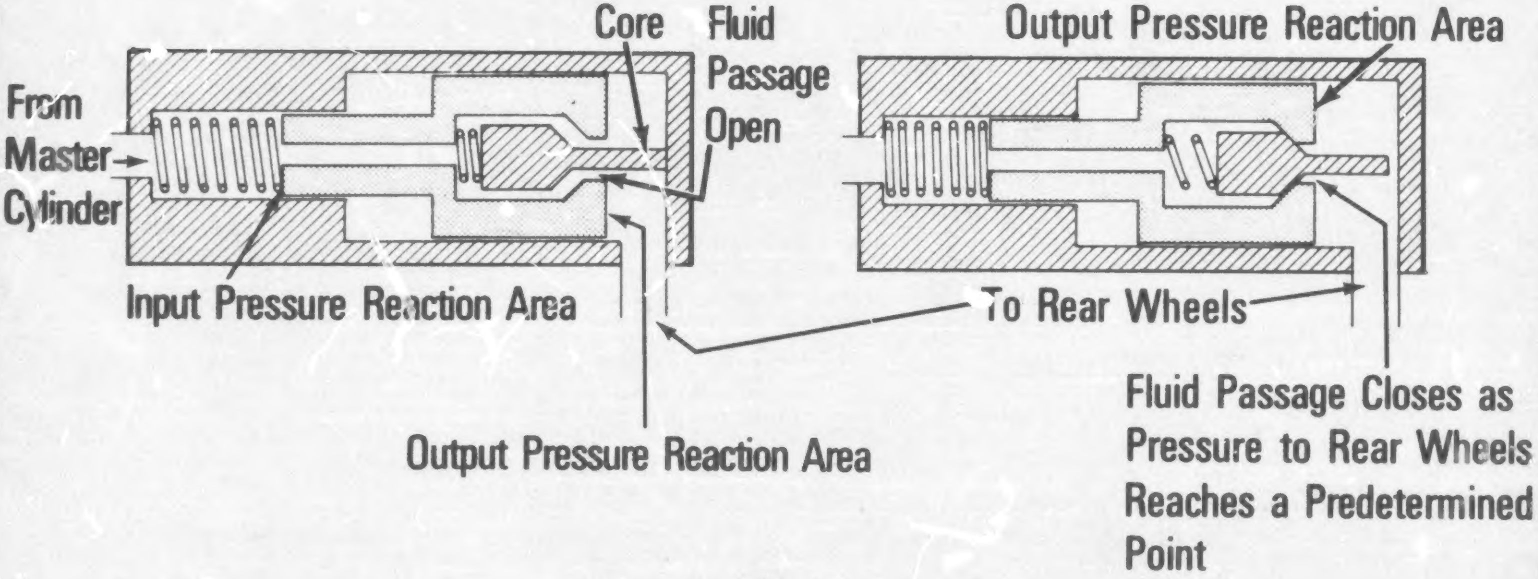
Valve in Failed Position


From Master Cylinder
To Front Wheels
Piston
Switch Terminal
Piston
To Rear Wheels

(Note: Equal Pressure in Both Front and Rear Hydraulic Systems.)

(Note: Pressure in the Front Hydraulic System is Low, Allowing the Higher Pressure in the Rear System to Move the Switch Piston to Turn on the Brake Warning Light .)

Operation of the Proportioning Valve



Released Position

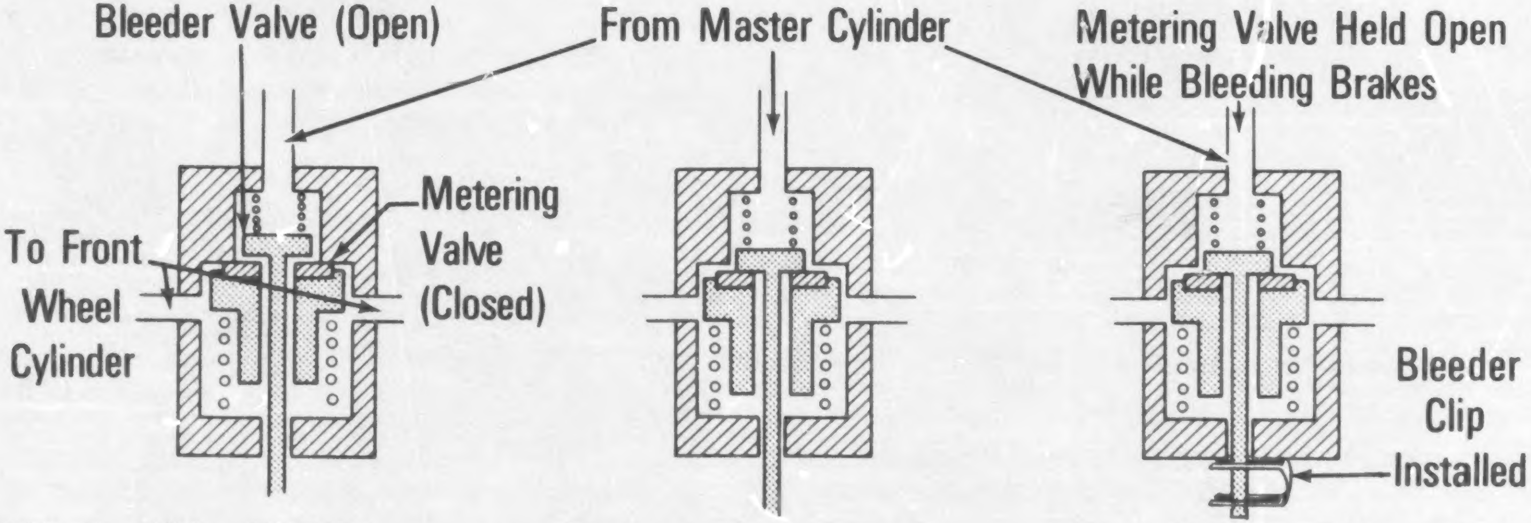
High Pressure Position

Core
Fluid Passage Open
From Master Cylinder
Input Pressure Reaction Area
Output Pressure Reaction Area
Output Pressure Reaction Area
To Rear Wheels
Fluid Passage Closes as Pressure to Rear Wheels Reaches a Predetermined Point

Proportioning Valve is Controling Hydraulic Pressure to Rear Wheels to Prevent Tire Skid as Weight of Vehicle Shifts from Rear to Front Wheels on Hard Stops

Operation of the Metering Valve

Released Position Applied Position Bleeder Position


Bleeder Valve (Open)
From Master Cylinder
Metering Valve Held Open While Bleeding Brakes
Metering Valve (Closed)
To Front Wheel Cylinder
Bleeder Clip Installed

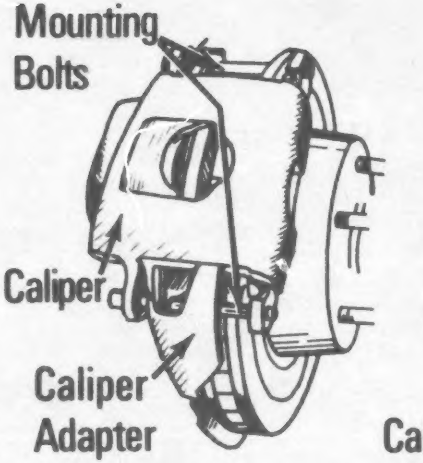
Bleeder Valve Remains Open Under 4 PSI to Allow Fluid to Expand and Contract

Pressure Above Approx. 150 PSI Opens the Metering Valve to Allow Pressure to Front Brakes

(Note: Metering Valves that have a Rubber Cover Over the Bleeder Valve Will Require the Valve to be Pushed in for Bleeding.)

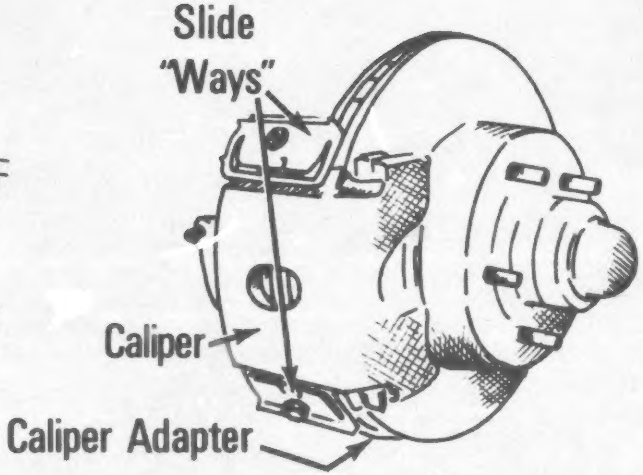
Types of Disc Brake Calipers

Floating


Mounting Bolts
Caliper
Caliper Adapter

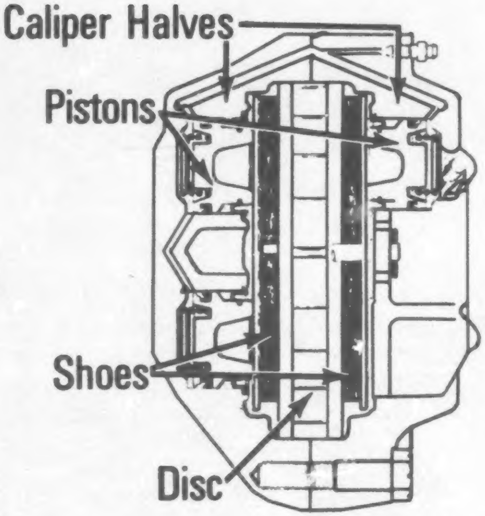
The Single Piston Caliper is Supported by and Floats on Two Mounting Bolts and the Braking Force is Exerted Against the Caliper Adapter

Sliding


Slide "Ways"
Caliper
Caliper Adapter

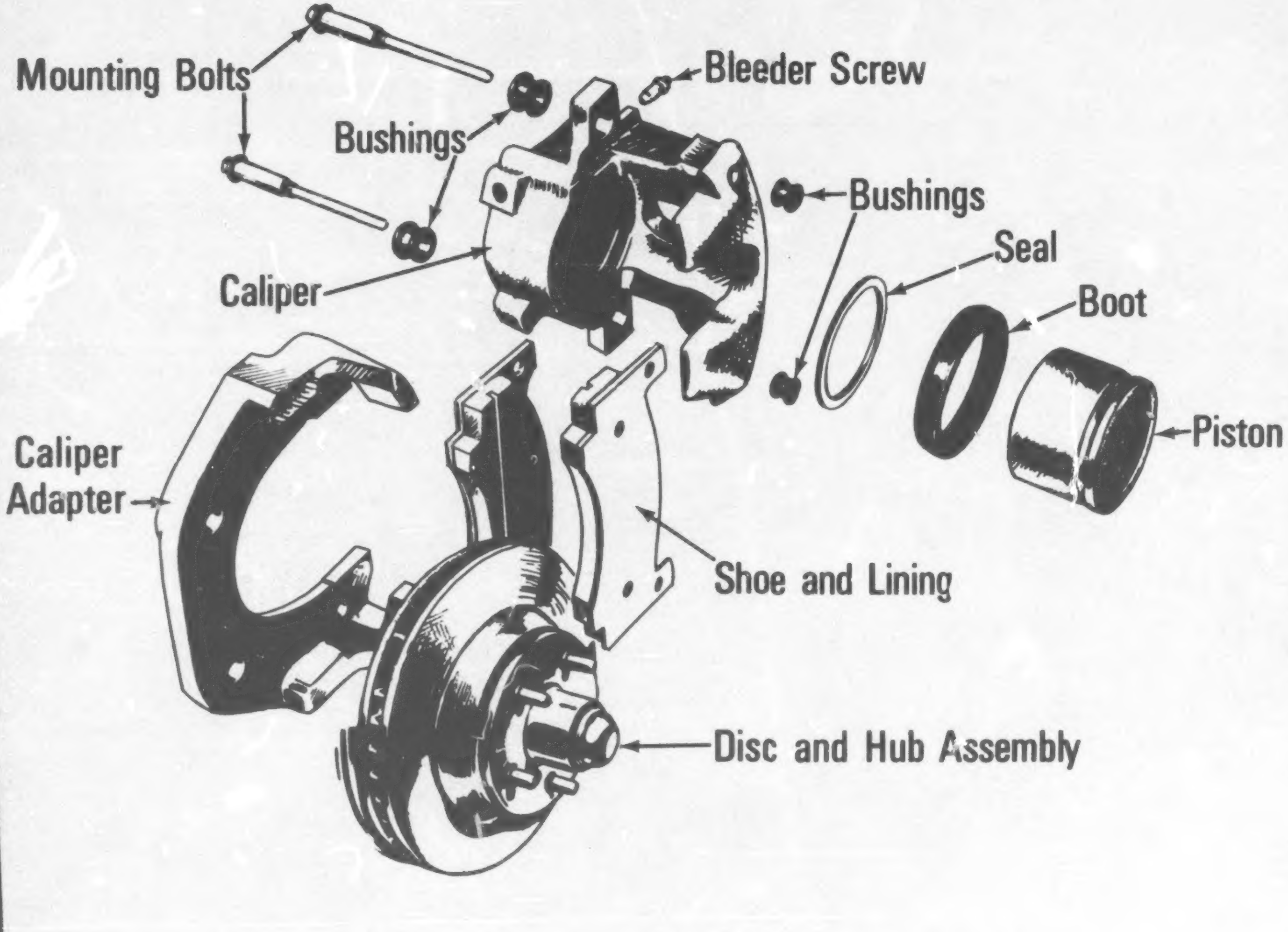
The Single Piston Caliper is Supported by and Free to Slide from Side to Side on Machined Ways in the Caliper Adapter, Which also Recieves the Braking Force

Fixed


Caliper Halves
Pistons
Shoes
Disc

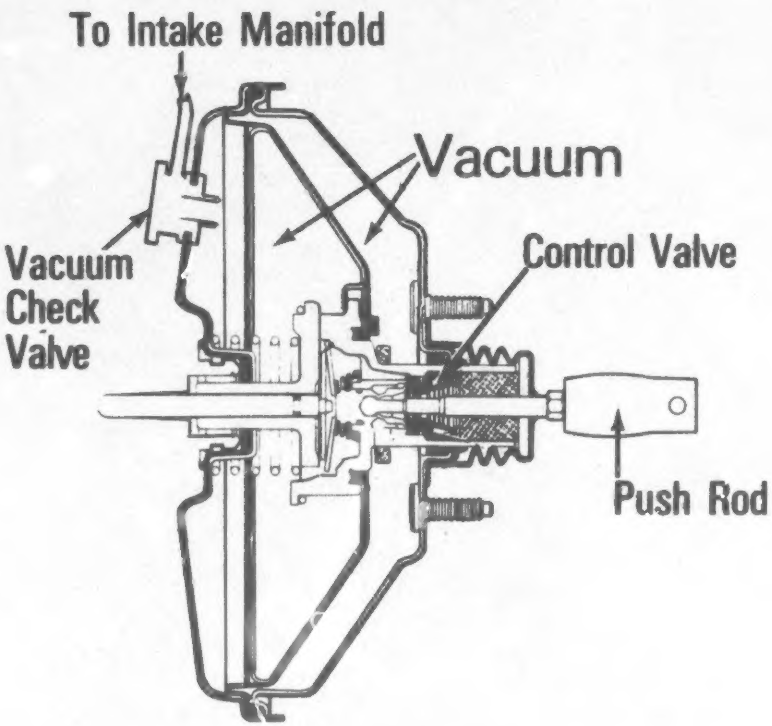
The Multi-Piston Caliper is Bolted Directly to the Steering Knuckle

Parts of a Floating Caliper Disc Brake

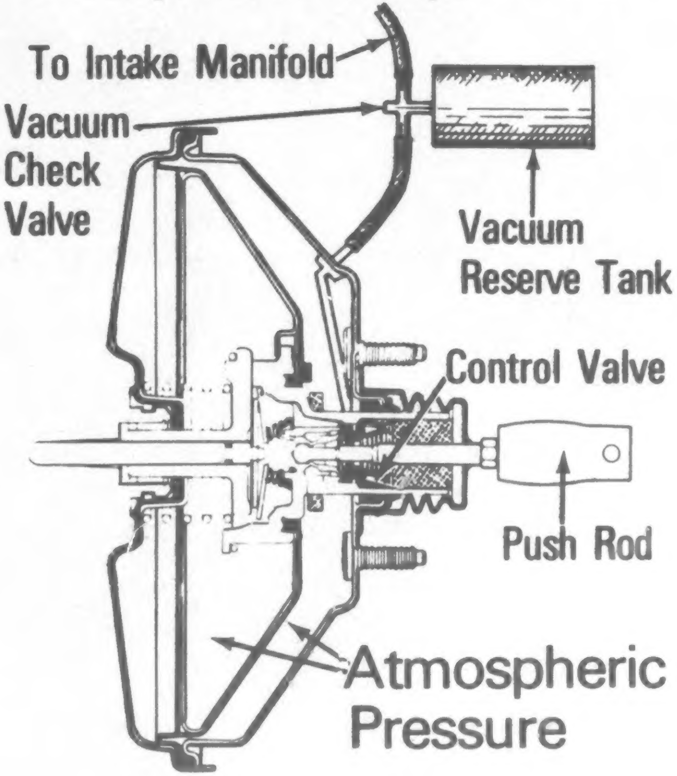

Mounting Bolts
Bleeder Screw
Bushings
Bushings
Seal
Caliper
Boot
Piston
Caliper Adapter
Shoe and Lining
Disc and Hub Assembly

Types of Vacuum Operated Power Boosters

Vacuum Suspended


To Intake Manifold
Vacuum
Control Valve
Vacuum Check Valve
Push Rod

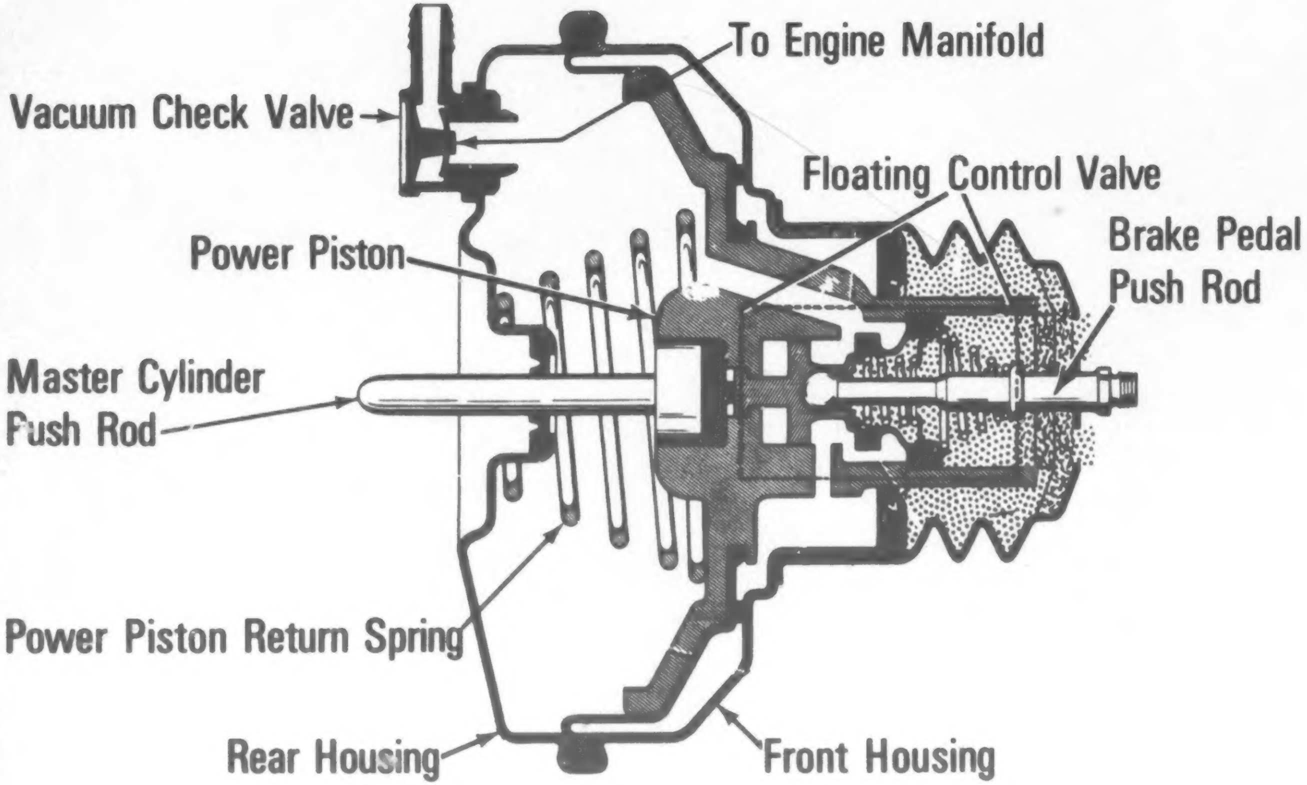
Atmospheric Suspended


To Intake Manifold
Vacuum Check Valve
Vacuum Reserve Tank
Control Valve
Push Rod
Atmospheric Pressure

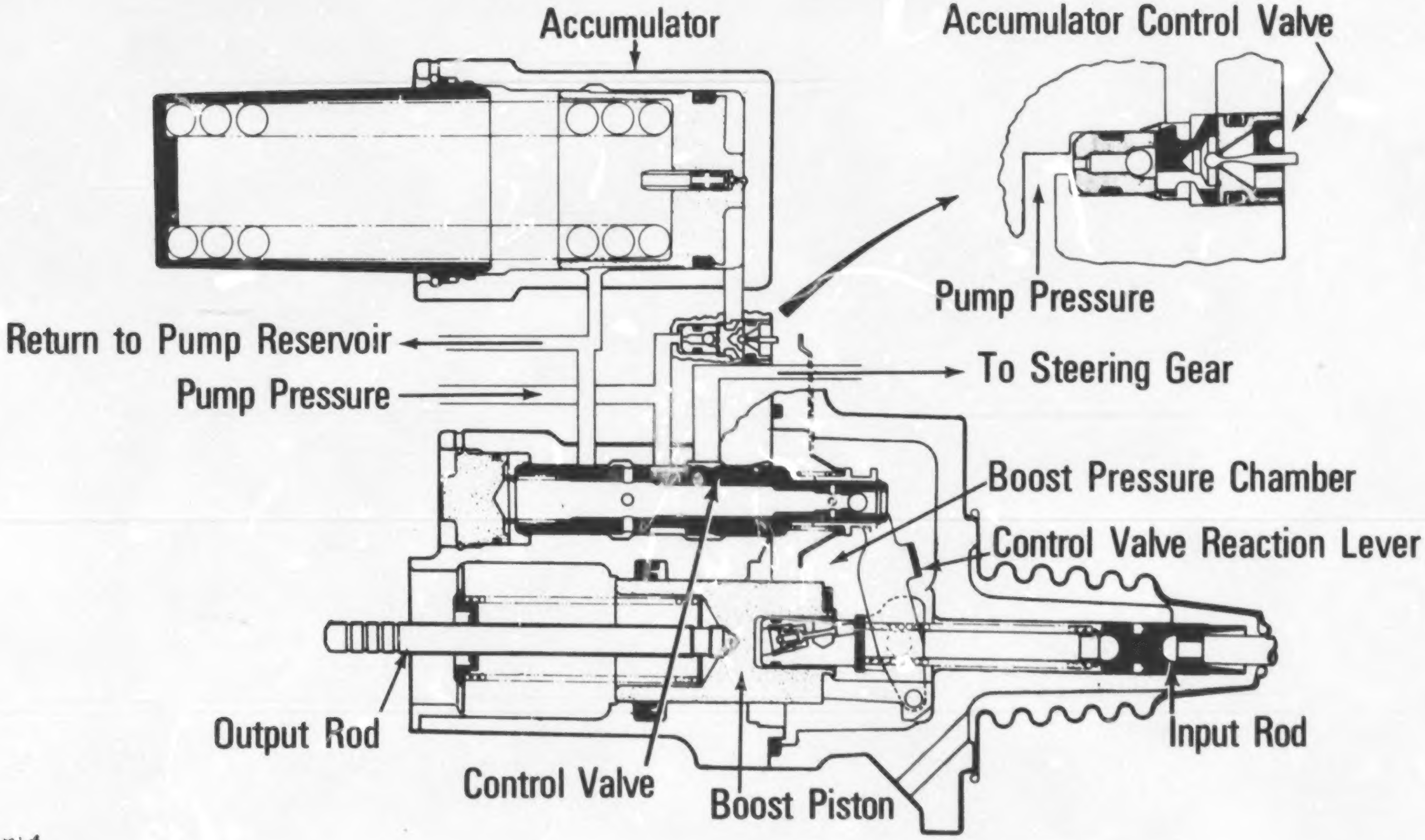
868

869

Major Parts of a Vacuum Operated Power Booster

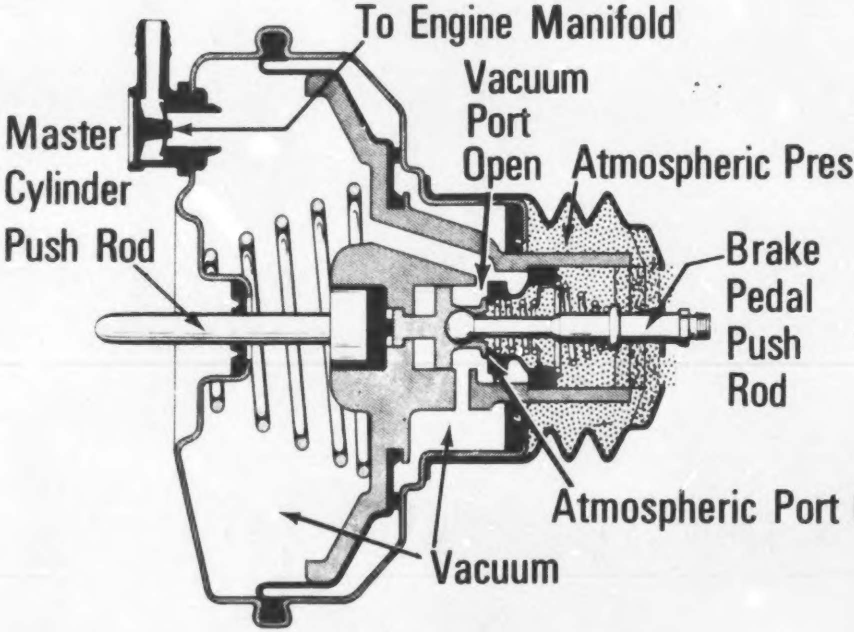

To Engine Manifold
Vacuum Check Valve
Floating Control Valve
Brake Pedal Push Rod
Power Piston
Master Cylinder Push Rod
Power Piston Return Spring
Rear Housing
Front Housing

Major Parts of a Hydro-Boost Power Booster

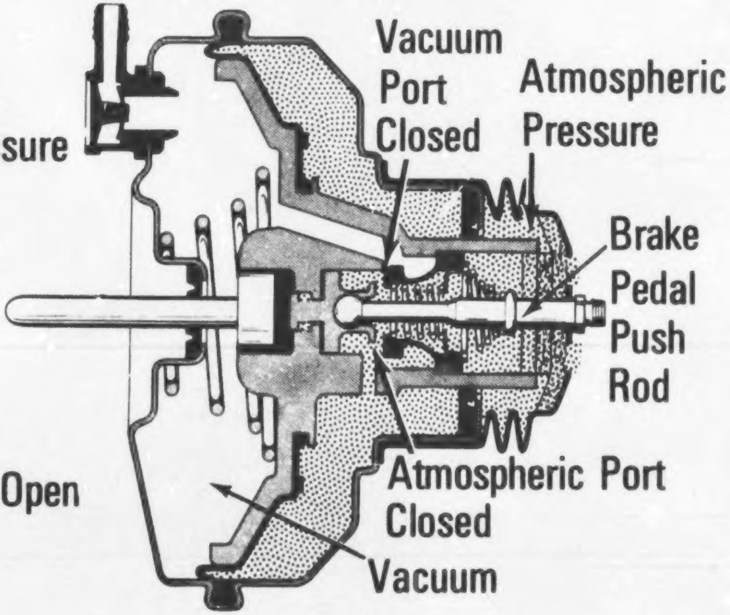

Accumulator
Accumulator Control Valve
Pump Pressure
Return to Pump Reservoir
To Steering Gear
Pump Pressure
Boost Pressure Chamber
Control Valve Reaction Lever
Output Rod
Input Rod
Control Valve
Boost Piston

Operation of the Vacuum Suspended Power Booster

Booster in the Released Position

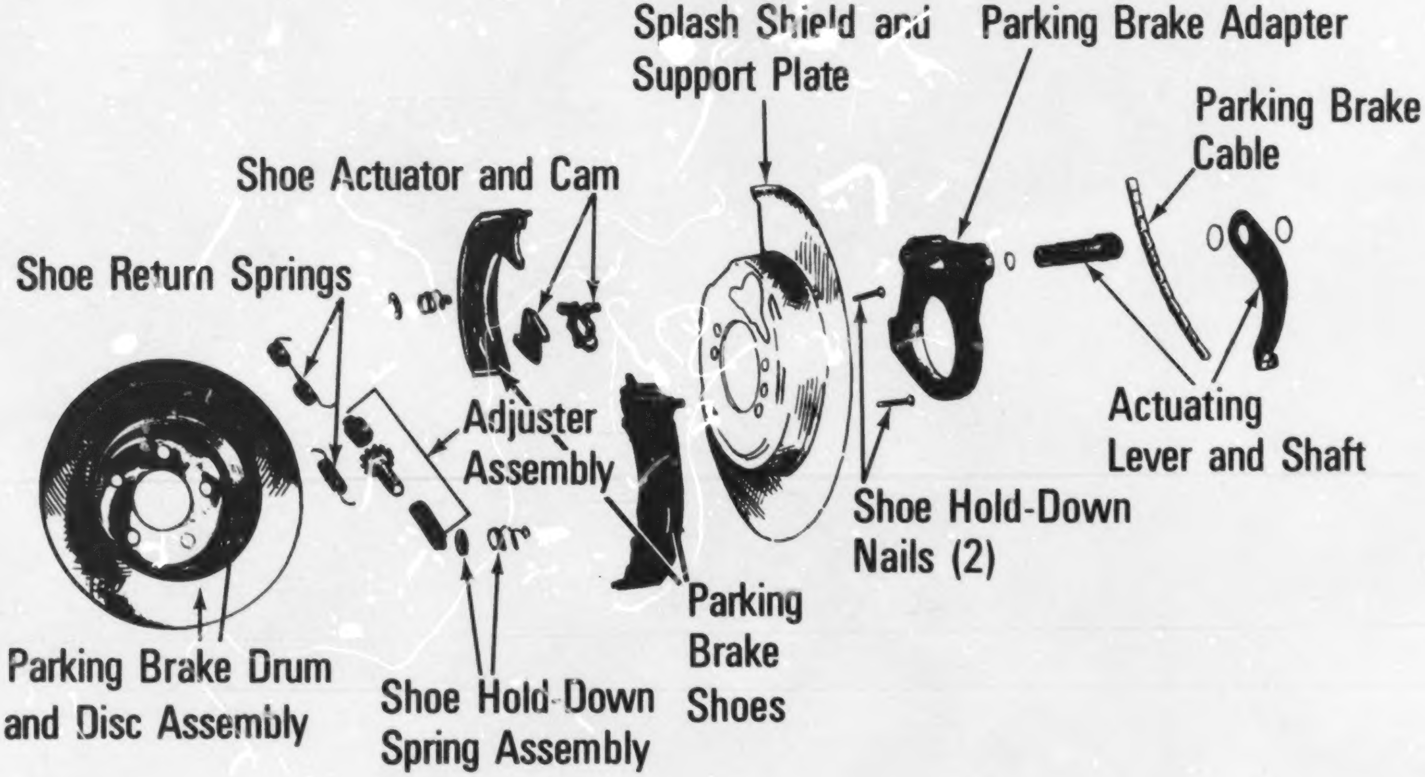

To Engine Manifold
Vacuum
Port
Open
Atmospheric Pressure
Master
Cylinder
Push Rod
Brake
Pedal
Push
Rod
Atmospheric Port Open
Vacuum

Booster in the Applying Position


Vacuum
Port
Closed
Atmospheric
Pressure
Brake
Pedal
Push
Rod
Atmospheric Port
Closed
Vacuum

Parts of Parking Brake on Four Wheel Disc Brake System

(Drum Type)


Splash Shield and
Support Plate
Parking Brake Adapter
Parking Brake
Cable
Shoe Actuator and Cam
Shoe Return Springs
Adjuster
Assembly
Actuating
Lever and Shaft
Shoe Hold-Down
Nails (2)
Parking
Brake
Shoes
Parking Brake Drum
and Disc Assembly
Shoe Hold-Down
Spring Assembly

POWER DISC BRAKES
UNIT II

JOB SHEET #1--TEST THE HYDRAULIC SYSTEM

I. Materials--Brake fluid (extra heavy-duty)

II. Procedure

(NOTE: Hydraulic brake systems DO NOT cause pulling, grabbing, vibrations, pulsating pedal, squeaks, squeals, clunks, or, in most cases, dragging brakes.)

A. Check fluid level in the master cylinder reservoir and fill to at least 1/4 inch (6.35mm) from top of the reservoir

B. Start the engine

(NOTE: This is necessary only on power brake models.)

C. Apply the brakes and hold a firm pressure for approximately two minutes; check for the following conditions:

1. Spongy pedal--Test for air entrapment in the hydraulic system with the aid of an assistant

(NOTE: A spongy pedal usually indicates air is trapped in the hydraulic system or shoes are not properly fitted to brake drum.)

a. Place the cap loosely on the master cylinder

b. Pump the brake pedal rapidly approximately 10 times

c. Hold pedal in the applied position on the final application

d. Remove the master cylinder cap

e. Release the pedal quickly and watch for a geyser of fluid spurting from the reservoir

(NOTE: If the fluid does form a geyser, bleed the hydraulic system.)

2. Brake warning light

(NOTE: The warning light indicates uneven hydraulic pressure between the front and rear brake systems which is usually caused by an external brake fluid leak.)

JOB SHEET #1

a. Check for fluid leaks at the master cylinder

b. Check for fluid leaks on all hydraulic lines and hoses

c. Check wheel cylinders for fluid leaks

d. Repair leaks as necessary

3. Excessive pedal travel

(NOTE: Excessive pedal travel is usually the result of shoes out of adjustment, an excessively worn shoe lining, or low fluid level in reservoir.)

a. Check fluid level and add fluid as necessary

(NOTE: If the reservoir is completely empty, the system will have to be bled.)

b. Remove the front tire and wheel assemblies

c. Inspect the caliper shoe linings

d. Remove the rear tire and wheel assemblies

e. Remove the rear brake drums

f. Inspect the shoe linings

g. Replace worn shoes as necessary

h. Replace the rear drums, tires, and wheels

i. Adjust rear brake shoes

j. Replace front tires and wheels

k. Bleed the hydraulic system

4. Pedal fade-away--Replace or overhaul the master cylinder

(NOTE: Pedal fade-away is the result of fluid leaking past the internal piston seals in the master cylinder.)

D. Recheck brake pedal action after proper repairs have been made

E. Road test, if the conditions have been corrected, to check if other problems may exist

POWER DISC BRAKES
UNIT II

JOB SHEET #2--TEST THE VACUUM POWER BOOSTER

I. Tools

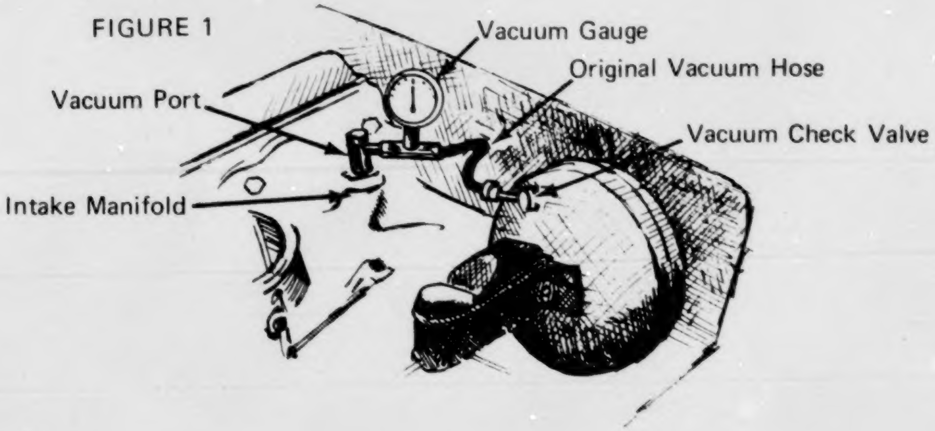
   A. Brake fluid (extra heavy-duty)

   B. Vacuum gauge

II. Procedure

   A. Attach the vacuum gauge to an intake manifold vacuum connection (Figure 1)

FIGURE 1


Vacuum Gauge
Original Vacuum Hose
Vacuum Port
Vacuum Check Valve
Intake Manifold

   B. Start the engine and take vacuum reading at idle speed

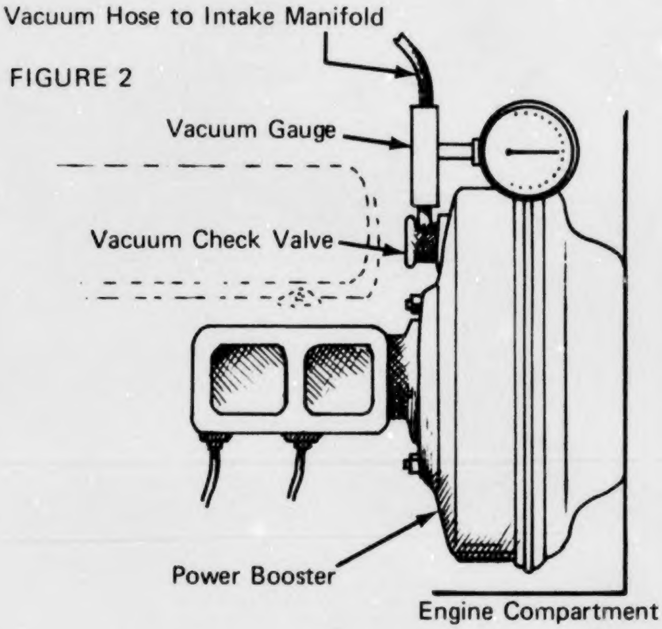
      (NOTE: The gauge should read at least 10 inches vacuum. If it reads less than 10 inches, the engine will require repairs to correct this condition.)

   C. Turn the engine off and remove the vacuum gauge from the engine connection

JOB SHEET #2

D. Connect the gauge in the vacuum hose at the power booster check valve (Figure 2)

FIGURE 2


Vacuum Hose to Intake Manifold
Vacuum Gauge
Vacuum Check Valve
Power Booster
Engine Compartment

E. Start the engine

F. Take a vacuum reading at idle speed

(NOTE: The vacuum reading should be the same as the reading taken at the manifold. If the reading is lower, check for a leak or restriction in the hose.)

G. Turn the engine off

H. Remove the vacuum gauge

I. Check fluid in the master cylinder reservoir and adjust as necessary

J. Shift the transmission into neutral

K. Depress the brake pedal several times to exhaust all vacuum in the system

L. Hold the brake pedal in the applied position

JOB SHEET #2

M. Start the engine

(NOTE: If the vacuum system is operating, the pedal will tend to fall away under foot pressure and less pressure will be required to hold the pedal in the applied position. Replace the power booster if a reaction is not felt on the pedal.)

N. Check for reserve vacuum leaks

1. Operate the engine at fast idle for 10 seconds and then stop the engine
2. Let the vehicle stand for 10 minutes
3. Apply the brake pedal with approximately 20 pounds of force

   (NOTE: The pedal feel should be the same as that noted with the engine operating. If the pedal feels hard, replace the vacuum check valve and retest for leaks. If pedal still feels hard, replace the power booster.)

POWER DISC BRAKES
UNIT II

JOB SHEET #3--REPAIR A SLIDING CALIPER DISC BRAKE

I. Tools

  A. Floor jack

  B. Jack stands

  C. Combination wrench set

  D. Screwdriver set

  E. Wire brush

  F. Brake hone

  G. Brake fluid

  H. C-clamp

  I. Hammer

  J. Drill motor

  K. Appropriate cleaning fluid for brake parts

  L. Bleeding equipment

  M. Metering valve bleeder clip

II. Procedure

  A. Raise vehicle and place on jack stands

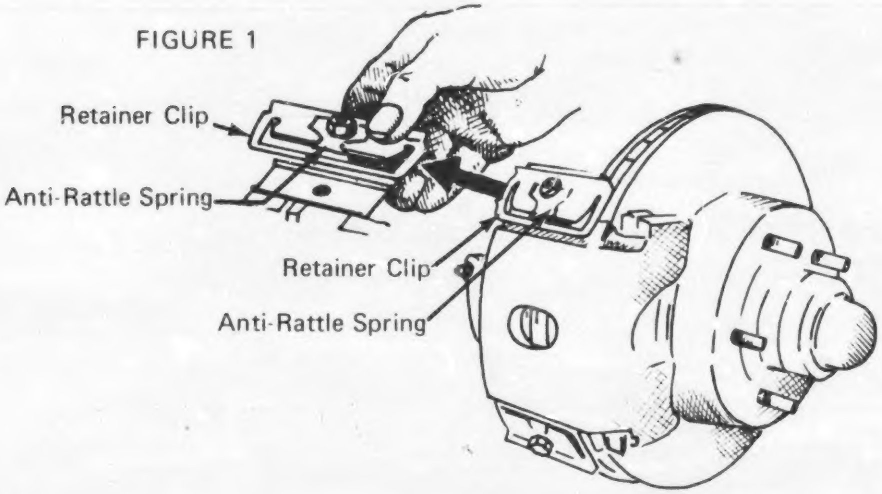
  B. Remove front wheel covers

  C. Remove wheel and tire assembly

JOB SHEET #3

D. Remove caliper anti-rattle springs and retainer clips (Figure 1)

FIGURE 1

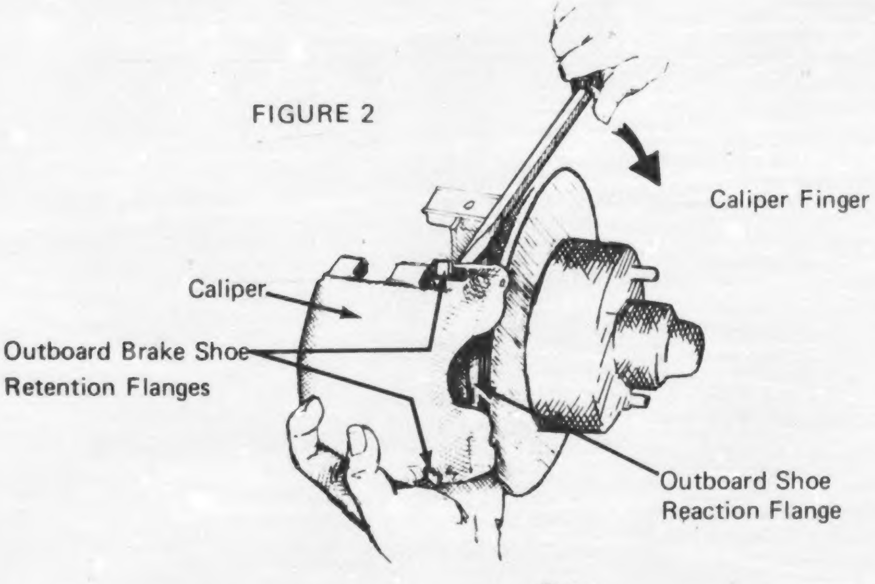

Retainer Clip
Anti-Rattle Spring
Retainer Clip
Anti-Rattle Spring

E. Remove caliper assembly from the disc by lifting the caliper straight out of the caliper adapter

(CAUTION: Support the caliper so that the weight is not suspended by the brake hose.)

F. Remove the outboard shoe from the caliper (Figure 2)

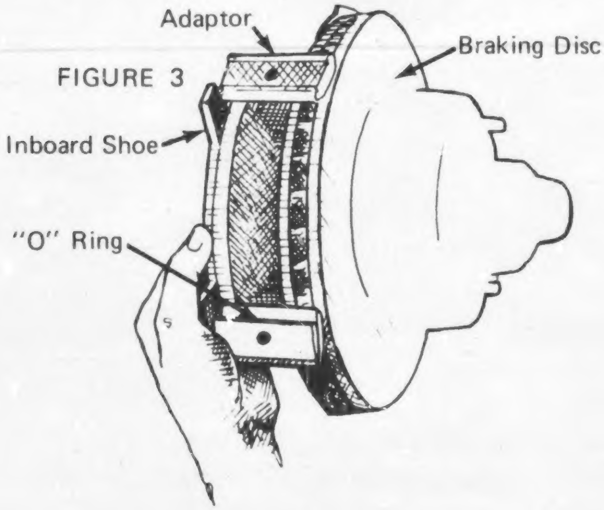
FIGURE 2


Caliper Finger
Caliper
Outboard Brake Shoe Retention Flanges
Outboard Shoe Reaction Flange

JOB SHEET #3

G. Remove the inboard shoe from the caliper adapter (Figure 3)

FIGURE 3

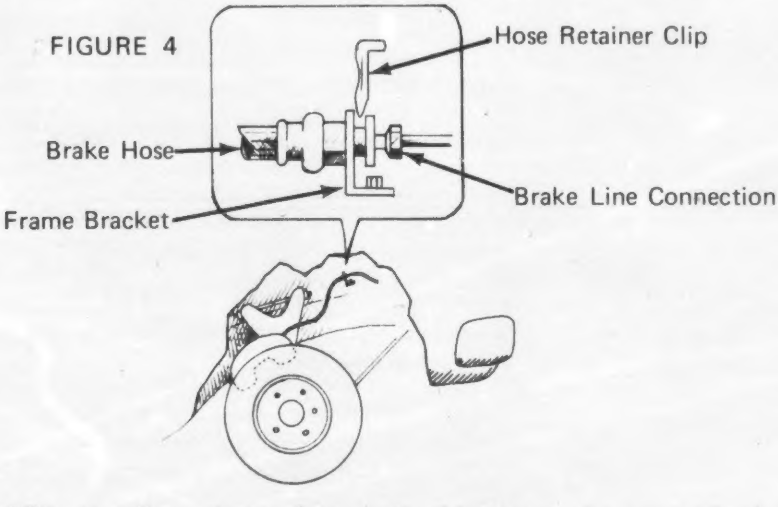

Adaptor
Braking Disc
Inboard Shoe
"O" Ring

H. Lay caliper assembly on shop towels on the upper control arm

I. Pump master cylinder slowly until the piston is pushed out of the caliper

J. Disconnect brake hose at frame connecter (Figure 4)

FIGURE 4


Hose Retainer Clip
Brake Hose
Brake Line Connection
Frame Bracket

(NOTE: If caliper pistons from both sides are to be removed, plug the line at the frame connector and remove the other piston.)

K. Clamp caliper in vise

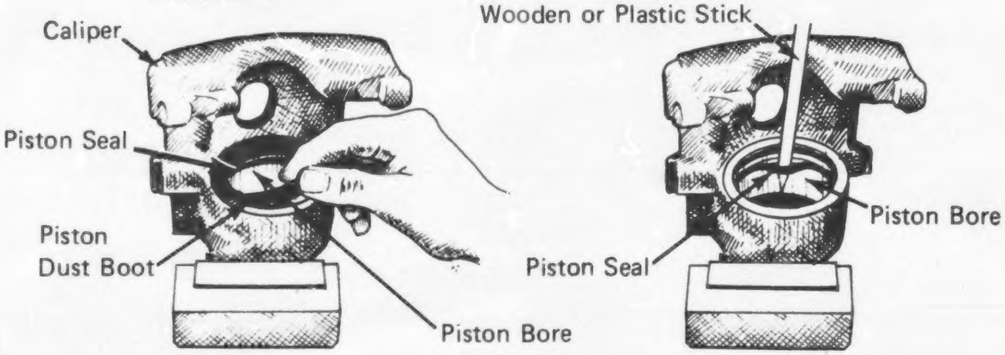
(CAUTION: Excessive vise pressure can damage caliper and cylinder.)

JOB SHEET #3

L. Remove the piston dust boot (Figure 5)

M. Remove the piston seal (Figure 5)

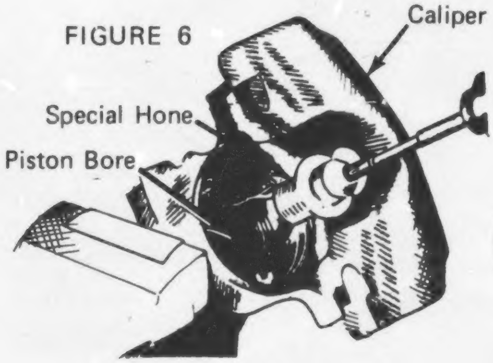
FIGURE 5


Caliper
Piston Seal
Piston
Dust Boot
Piston Bore
Wooden or Plastic Stick
Piston Bore
Piston Seal

N. Hone the cylinder to remove any scratches or corrosion

(CAUTION: Do not increase the diameter of the cylinder more than 0.002 inch. If the cylinder will not clean up within this specification, the caliper will have to be replaced. See Figure 6.)

FIGURE 6


Caliper
Special Hone
Piston Bore

O. Clean the caliper very carefully to remove all dirt and grit by flushing the cylinder with clean brake fluid

P. Clean the piston with alcohol or a suitable cleaner

JOB SHEET #3

Q. Inspect the piston for scratches or corrosion

(NOTE: If pits or scratches are found, the piston will have to be replaced.)

R. Clamp caliper in vise with protected jaws

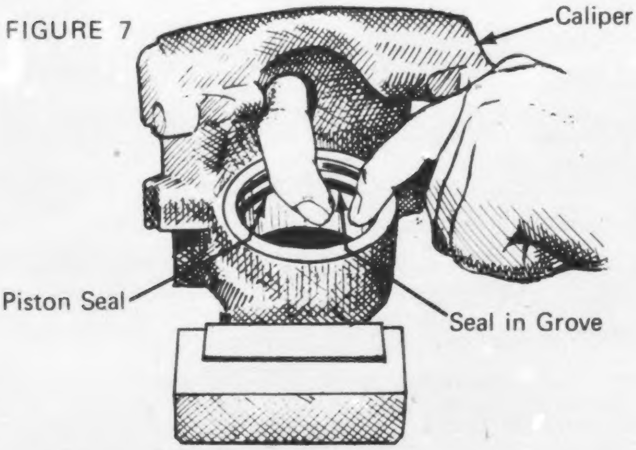
(CAUTION: Excessive vise pressure will cause bore distortion and binding of piston.)

S. Lubricate the new caliper piston seal with brake fluid

(NOTE: Some manufacturers provide a special lubricant with the new seals; this should be used instead of brake fluid.)

T. Install seal into caliper cylinder groove making sure not to have a twist in the seal (Figure 7)

FIGURE 7

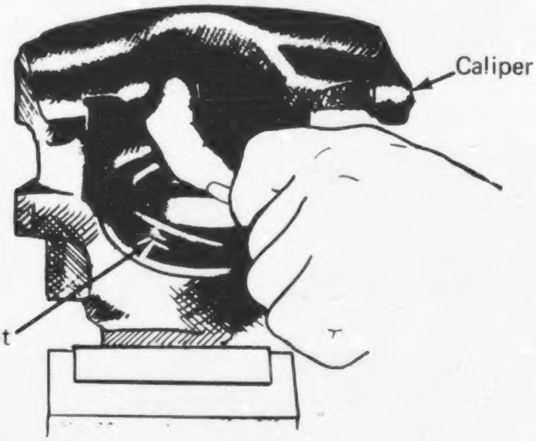


U. Lubricate the piston dust boot

JOB SHEET #3

V. Install dust boot into groove (Figure 8)

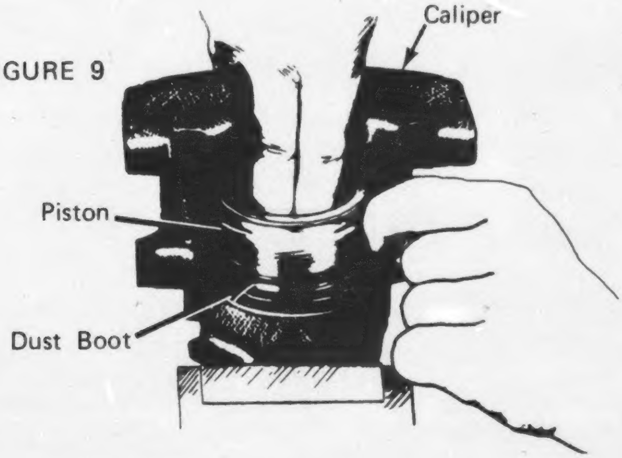
FIGURE 8


Caliper
Piston Dust Boot

W. Plug the pressure inlet hole and close the bleeder

X. Coat the piston with brake fluid and start it into the dust boot (Figure 9)

FIGURE 9


Caliper
Piston
Dust Boot

(NOTE: Air entrapped below piston will force boot around piston.)

Y. Align and start the piston into piston seal

Z. Remove the plug from inlet port

JOB SHEET #3

AA. Push piston down the bore carefully until bottomed

(CAUTION: Force should be applied uniformly to avoid rocking the piston.)

BB. Install outboard shoe into caliper with a slight interference fit

(CAUTION: No clearance should exist between caliper and shoe flanges. Bend flanges to eliminate any vertical movement. See Figures 10 and 11.)

FIGURE 10

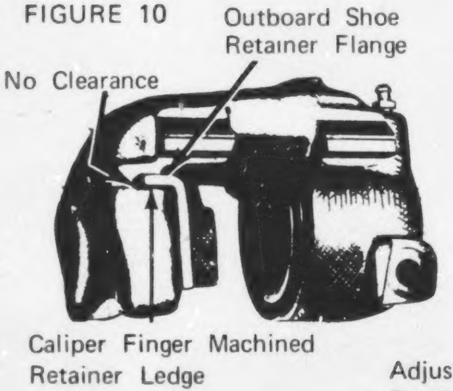
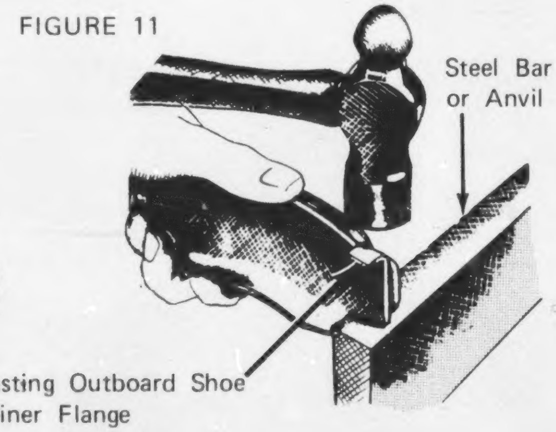

Outboard Shoe Retainer Flange
No Clearance
Caliper Finger Machined Retainer Ledge

FIGURE 11

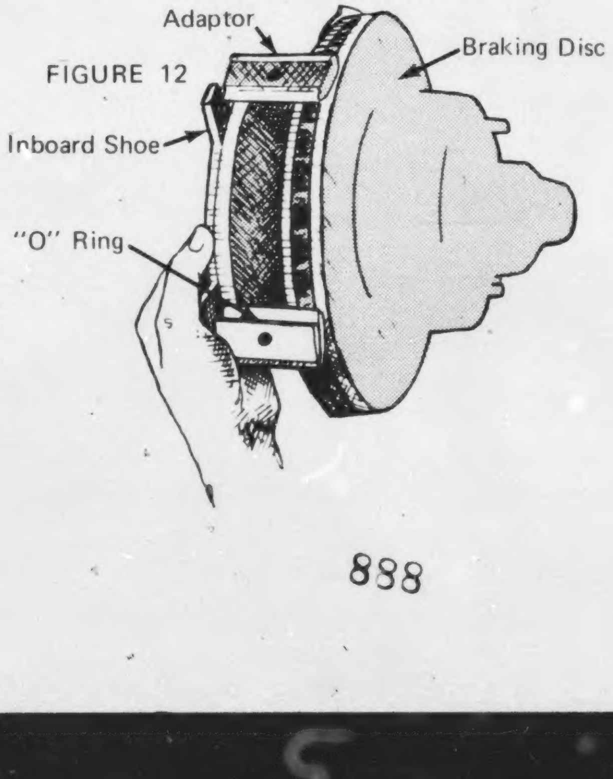

Steel Bar or Anvil
Adjusting Outboard Shoe Retainer Flange

CC. Remove "O" rings from caliper adapter and clean adapter "ways" with a wire brush (Figure 12)

DD. Replace "O" rings on caliper adapter

EE. Position inboard shoe in caliper adapter (Figure 12)

FIGURE 12


Adaptor
Braking Disc
Inboard Shoe
"O" Ring

JOB SHEET #3

FF. Slide caliper assembly slowly into position in adapter over disc

(CAUTION: Avoid damage to caliper piston dust cover as it passes over the inboard shoe.)

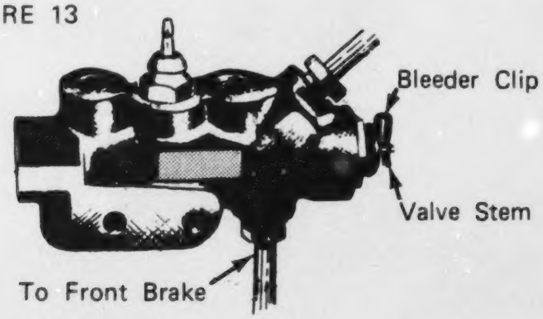
GG. Install anti-rattle springs and retaining clips and torque the retaining screws to specifications

HH. Connect brake hose at the frame

II. Bleed the air from the system

(NOTE: For systems with metering valves, it will be necessary to install a bleeder clip on the valve stem when using a pressure bleeder. See Figure 12.)

FIGURE 13



JJ. Replace wheel and tire assembly

KK. Replace wheel cover

LL. Lower vehicle to the floor

MM. Road test with the instructor to check for proper operation

POWER DISC BRAKES
UNIT II

JOB SHEET #4--CHECK DISC RUNOUT AND THICKNESS

I. Tools

   A. Floor jack

   B. Jack stands

   C. Dust cover remover tool

   D. Combination wrench set

   E. Screwdriver set

   F. Pinch bar

   G. Dial indicator with attachments

   H. Micrometers, 0 - 1" and 1" - 2"

   I. Diagonal cutting pliers

   J. Torque wrench

   K. Socket to fit spindle nut

   L. Cotter pin

   M. Straightedge

   N. Feeler gauge

II. Procedure

   A. Raise vehicle and place on jack stands

   B. Remove wheel cover

   C. Remove wheel and tire assembly

   D. Remove hub dust cover

   E. Remove cotter pin

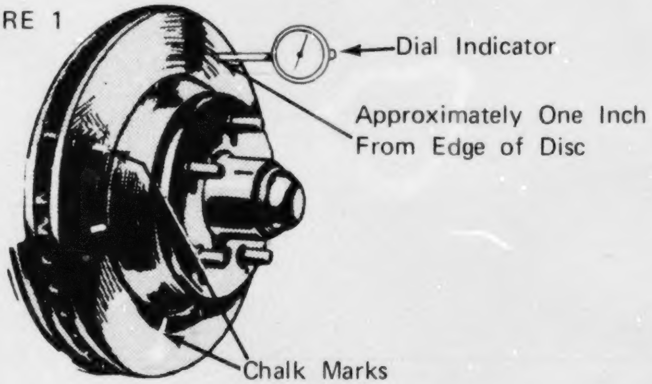
   F. Adjust wheel bearing to zero clearance

JOB SHEET #4

G. Attach dial indicator to some portion of the suspension so that the indicator point will ride on the disc approximately one inch from the outer edge (Figure 1)

H. Mark the disc with chalk every 30° of rotation (Figure 1)

FIGURE 1


Dial Indicator
Approximately One Inch From Edge of Disc
Chalk Marks

I. Set the dial indicator to "0"

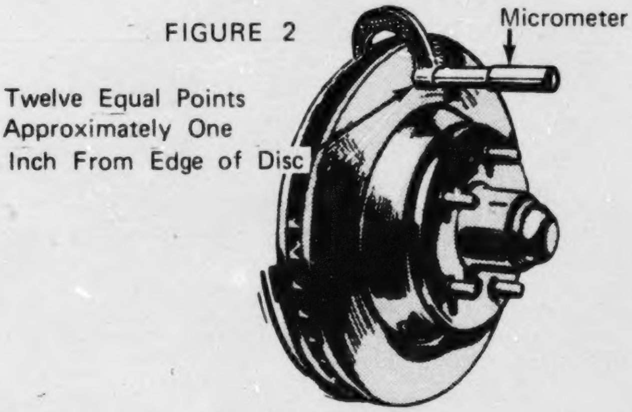
J. Rotate the disc and check runout

(NOTE: Total runout should not exceed 0.005 inch in 360° and should not have more than 0.001 inch variation in 30° rotation. If disc is not within these limits, it will have to be reconditioned or replaced.)

K. Remove the disc and hub assembly from the spindle

L. Measure the disc approximately one inch from the outer edge with the appropriate size micrometer (Figure 2)

FIGURE 2

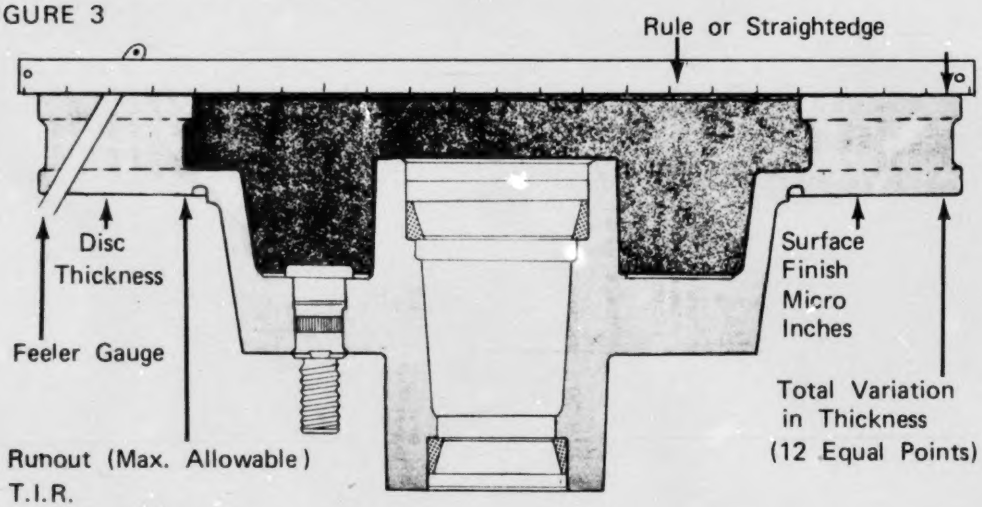

Micrometer
Twelve Equal Points Approximately One Inch From Edge of Disc

(NOTE: Measure at least four places equally spaced around the disc. Thickness variation must not exceed 0.0005 inch. If the thickness varies over 0.0005 inch, the disc will have to be reconditioned or replaced.)

JOB SHEET #4

M. Check disc for flatness with a straightedge and feeler gauge across the disc diameter (Figure 3)

FIGURE 3


Rule or Straightedge
Disc Thickness
Feeler Gauge
Runout (Max. Allowable) T.I.R.
Surface Finish Micro Inches
Total Variation in Thickness (12 Equal Points)

N. Check disc for heavy scoring, rust pitting, or wear; resurface or replace as necessary

(NOTE: Light scoring or wear is acceptable and will not affect the brake operation.)

O. Check for cracks in the disc or hub

(NOTE: If cracks are found, the disc and hub assembly must be replaced.)

P. Replace the disc and hub assembly on the vehicle and adjust wheel bearings

Q. Replace the caliper assembly

R. Replace tire and wheel assembly

S. Replace wheel cover

T. Pump the brake pedal several times to position the shoes and piston to the disc

U. Lower the vehicle to the floor

V. Road test with the instructor

POWER DISC BRAKES
UNIT II

TEST

1. Match the terms on the right to the correct definitions.

______a. Brake system utilizing a caliper which compresses brake shoes against a circular disc

______b. Condition caused by heat or moisture that decreases friction and the braking power of the system

______c. Larger action that results from a smaller input action

______d. Vacuum or hydraulic operated unit that is designed to assist the driver when applying the brakes

______e. Resistance to relative movement between two bodies in contact

______f. Power assist unit operated by hydraulic pressure from the power steering pump

______g. Pressure lower than atmospheric pressure developed in the engine intake manifold and cylinders by the movement of the pistons in the cylinders

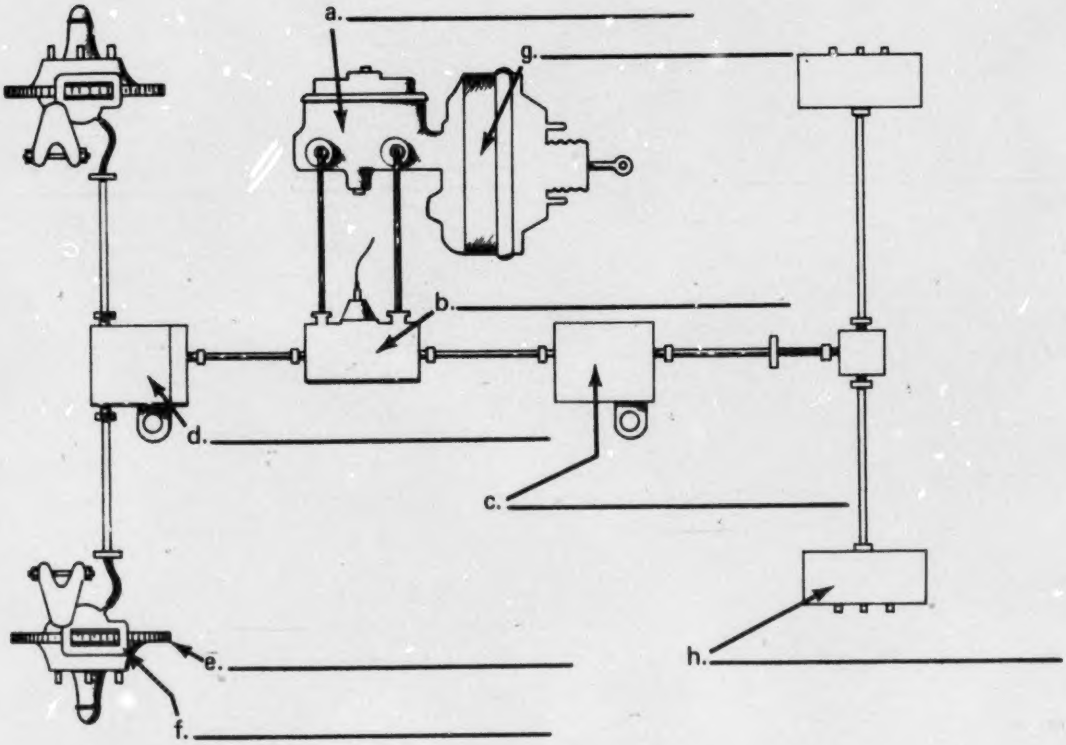
______h. Shoe next to the single piston in the caliper and on the vehicle frame side of the brake disc

______i. Shoe opposite the caliper piston and outside the brake disc

______j. Department of Transportation; federal government agency whose function is to set standards for safety items on motor vehicles

1. Hydro-boost
2. Power booster
3. Disc brakes
4. Friction
5. Inboard shoe
6. Manifold vacuum
7. DOT
8. Brake fade
9. Servo action
10. Outboard shoe

2. Identify the major components of the disc brake system in the illustration below.



3. Match the disc brake system components on the right to the correct functions.

______a. Regulates the hydraulic pressure to the front disc brakes in the 3 to 135 psi range to allow the rear drum brake shoes to begin brake action to prevent locking of the front brakes especially on icy or slick surfaces

______b. Senses unbalanced pressure between the front and rear brake systems and causes the warning light to shine

______c. Contains friction linings and a hydraulic piston to supply force on the linings to stop the rotor

______d. Forces brake fluid into all wheel cylinders when brakes are applied

______e. Assists the driver in applying the brakes

______f. Regulates rear brake system hydraulic pressure to prevent premature rear wheel skid on emergency stops

______g. Provides a friction surface for the lining to exert a force resisting the rotation of the wheel

1. Pressure differential valve
2. Master cylinder
3. Disc or rotor assembly
4. Metering valve
5. Proportioning valve
6. Power booster unit
7. Caliper assembly

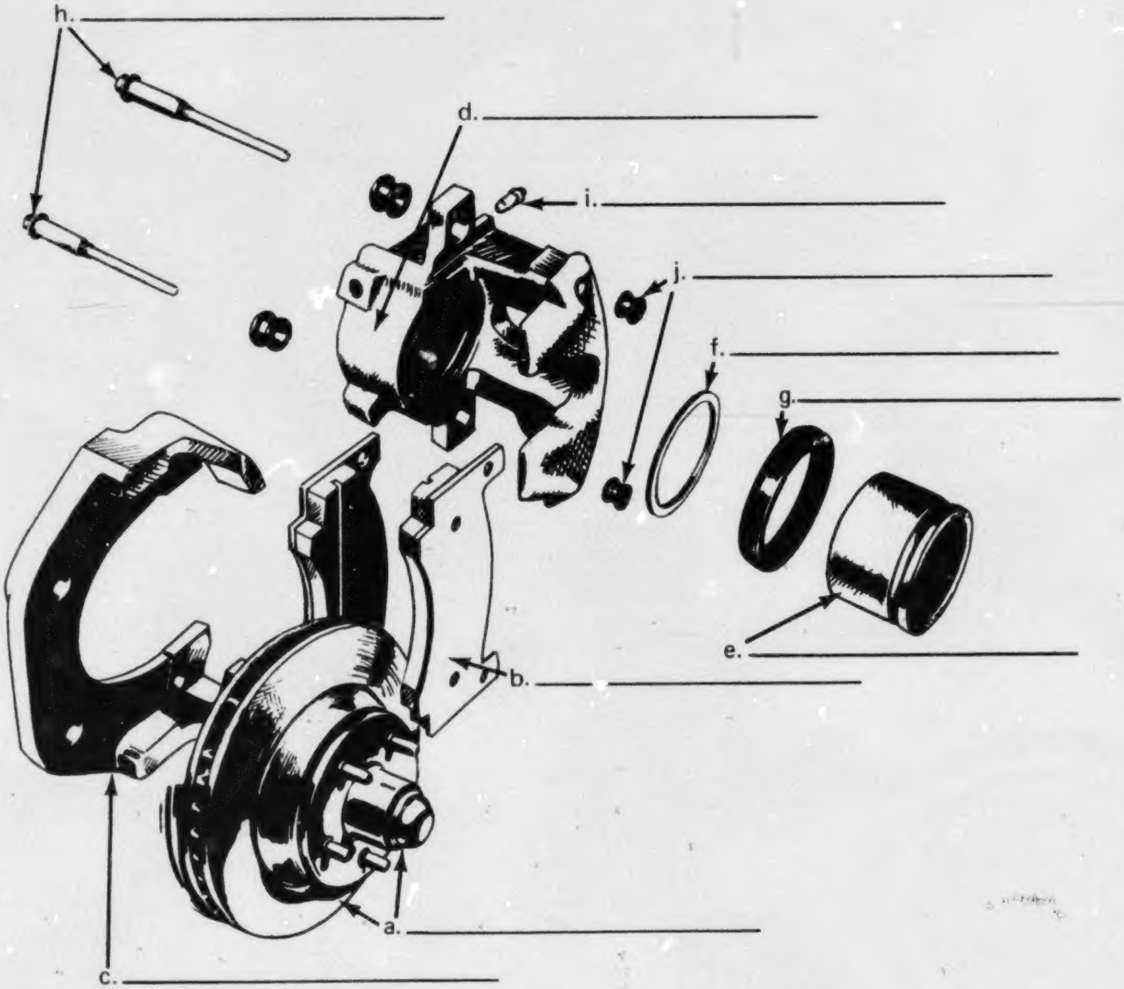
4. List the three types of disc brake calipers.

a.

b.

c.

5. Identify the parts of the floating caliper disc brake in the illustration below.


h. ______
d. ______
i. ______
j. ______
f. ______
g. ______
e. ______
b. ______
a. ______
c. ______

6. List good characteristics of disc brakes.

a.

b.

c.

d.

e.

7. Discuss reasons disc brakes may require power booster units.

8. List two sources of energy used for power boosters.

a.

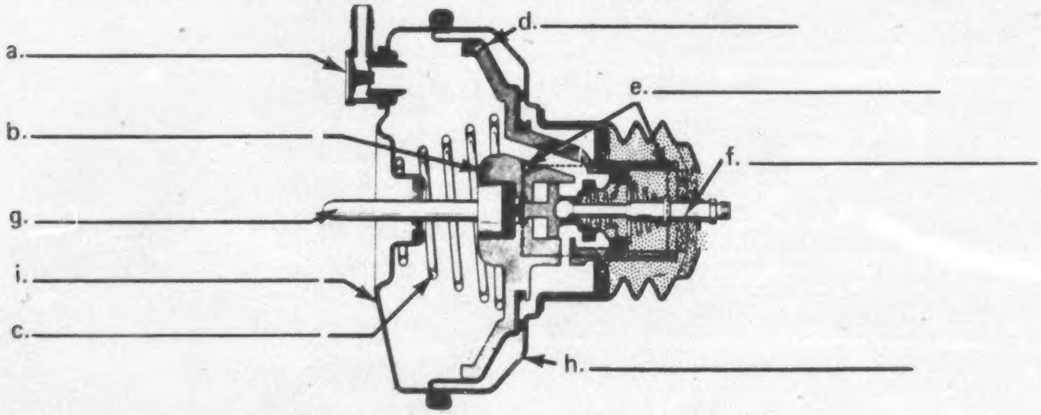
b.

9. List two types of vacuum operated power boosters.

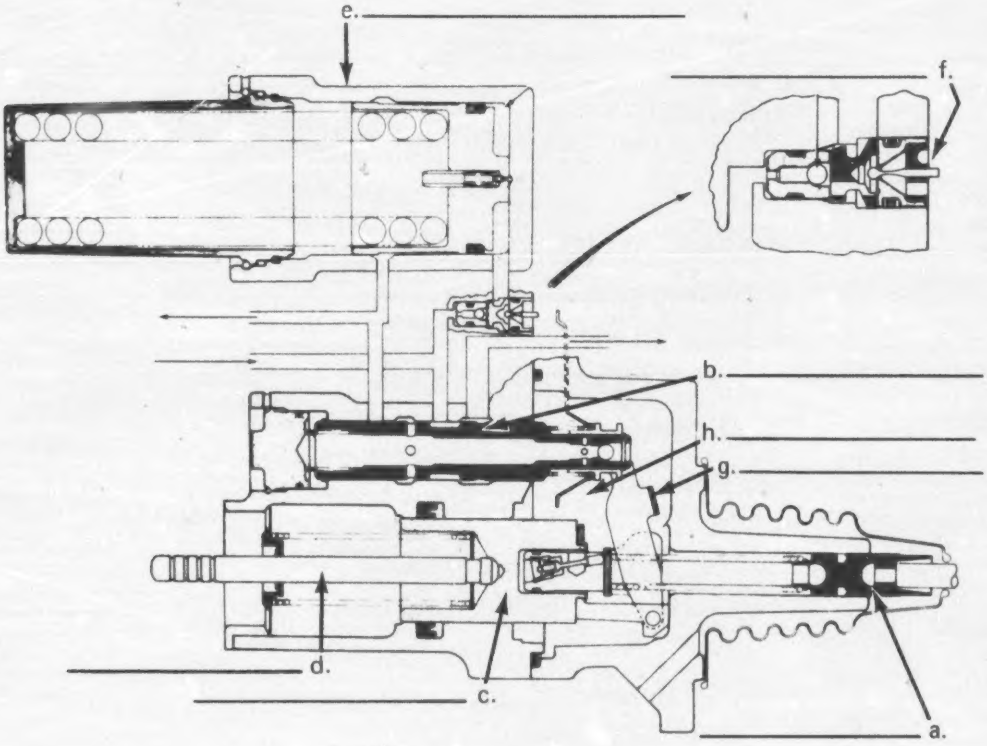
a.

b.

10. Identify the parts of the vacuum operated power booster in the illustration below.



11. Identify major parts of the hydro-boost power booster in the illustration below.



12. Discuss briefly the operation of the vacuum suspended power booster.

13. Discuss briefly the operation of the atmospheric suspended power booster.

14. Discuss briefly the operation of the hydro-boost power booster.

15. List six requirements of super heavy-duty brake fluid.

a.

b.

c.

d.

e.

f.

16. Discuss conditions that are considered normal and are not indications that master cylinder needs service.

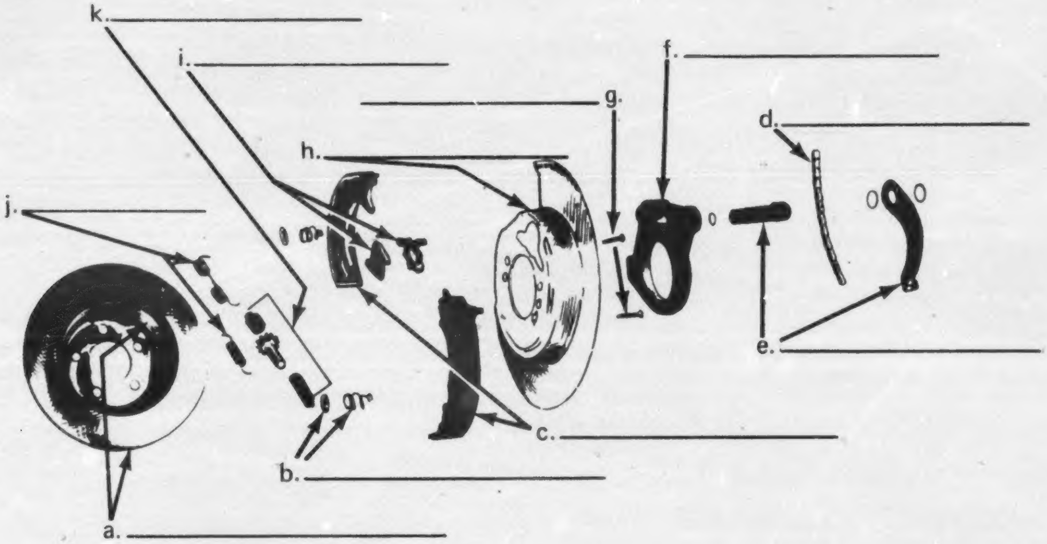
    a. Unequal brake fluid levels in master cylinder reservoir--

    b. Momentary or slight squirt of brake fluid from one or both master cylinder reservoir chambers upon application of the brake pedal--

    c. Slight turbulence in reservoir fluid occurring when the brake pedal is released--

    d. A trace of brake fluid on the power booster housing below the master cylinder mounting flange--

17. Identify the parts of the parking brake system on four wheel disc brakes in the illustration below.



18. Demonstrate the ability to:

- a. Test the hydraulic system.
- b. Test the vacuum power booster.
- c. Repair a sliding caliper disc brake.
- d. Check disc runout and thickness.

(NOTE: If the above activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

POWER DISC BRAKES
UNIT II

ANSWERS TO TEST

1. a. 3
   b. 8
   c. 9
   d. 2
   e. 4
   f. 1
   g. 6
   h. 5
   i. 10
   j. 7

2. a. Master cylinder
   b. Pressure differential valve
   c. Proportioning valve
   d. Metering valve
   e. Front disc or rotor assembly
   f. Caliper assembly
   g. Power booster unit
   h. Rear drum or disc brake assembly

3. a. 4
   b. 1
   c. 7
   d. 2
   e. 6
   f. 5
   g. 3

4. a. Fixed
   b. Floating
   c. Sliding

5. a. Disc and hub assembly
   b. Shoe and lining
   c. Caliper adapter
   d. Caliper

  - e. Piston
  - f. Seal
  - g. Boot
  - h. Mounting bolts
  - i. Bleeder screw
  - j. Bushings

6. a. Fade resistant
  - b. More even stopping of vehicle
  - c. More efficient in adverse conditions
  - d. Simple in design for easier maintenance
  - e. Better adapted to heavier vehicles

7. Discussion should include:
  - a. Disc brake shoes have no servo action
  - b. Disc shoe linings have less contact surface than drum brake shoes

8. a. Engine vacuum
  - b. Hydraulic pressure

9. a. Vacuum suspended
  - b. Atmospheric suspended

10. a. Vacuum check valve
  - b. Power piston
  - c. Power piston return spring
  - d. Diaphragm and valve body plate
  - e. Floating control valve
  - f. Brake pedal push rod
  - g. Master cylinder push rod
  - h. Front housing
  - i. Rear housing

11.
   a. Input rod
   b. Control valve
   c. Boost piston
   d. Output rod
   e. Accumulator
   f. Accumulator control valve
   g. Control valve reaction lever
   h. Boost pressure chamber

12. Discussion should include:
   a. In the at-rest position, vacuum is on both sides of the diaphragm
   b. As the brake pedal is applied, the pedal push rod actuates the control valve and allows atmospheric pressure to enter the front side of the diaphragm which assists the driver in applying force on the master cylinder piston
   c. The amount of force applied by the driver controls the amount of atmospheric pressure that can enter the chamber to control braking effort

13. Discussion should include:
   a. In the at-rest position, atmospheric pressure is on both sides of the diaphragm
   b. As the brake pedal is applied, the pedal push rod actuates the control valve which directs a controlled amount of vacuum to the back side of the diaphragm while the atmospheric pressure on the front side assists the driver in applying the brakes
   c. The force applied by the driver controls the amount of vacuum exerted in the chamber to control braking effort

14. Discussion should include:
   a. As the brake pedal is depressed, it moves the pedal rod and initiates movement of the control valve and allows fluid pressure from the power steering pump to enter the boost chamber to provide force on the boost piston to assist the driver in applying the brakes
   b. Additional movement of the brake pedal will restrict fluid flow between the power steering pump and steering gear causing the power steering pump to increase its pressure for more power assist if needed

15. a. High boiling point
    b. Low freezing point
    c. Consistent viscosity
    d. Noncorrosive
    e. Water tolerance
    f. Lubricating ability

16. Discussion should include:

    a. Unequal brake fluid levels in master cylinder reservoir--This condition is caused by displacement of fluid from the reservoir into the calipers to compensate for normal lining wear

    b. Momentary or slight squirt of brake fluid from one or both master cylinder reservoir chambers upon application of the brake pedal--This is caused by the fluid displacement through the cylinder compensating ports as the piston moves forward in the bore

    c. Slight turbulence in the reservoir fluid occurring when the brake pedal is released--This is the result of brake returning from the releasing wheel cylinders

    d. A trace of brake fluid on the power booster housing below the master cylinder mounting flange--Results from the lubricating action of the master cylinder wiping seal

17. a. Parking brake drum and disc assembly
    b. Shoe hold-down spring assembly
    c. Parking brake shoes
    d. Parking brake cable
    e. Actuating lever and shaft
    f. Parking brake adapter
    g. Shoe hold-down nails
    h. Splash shield and support plate
    i. Shoe actuator and cam
    j. Shoe return springs
    k. Adjuster assembly

18. Performance skills evaluated to the satisfaction of the instructor